December 2001

MONITORING AND EVALUATION OF SMOLT MIGRATION IN THE COLUMBIA BASIN

Volume IX: Evaluation of the 2001 Predictions of the Run-Timing of Wild and Hatchery-Reared Migrant Salmon and Steelhead Trout Migrating to Lower Granite, Rock Island, McNary, and John Day Dams using Program RealTime

Technical Report 2001

DOE/BP-00004134-1

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do not necessarily represent the views of BPA.

This document should be cited as follows:

Burgess, Caitlin, John R. Skalski - School of Fisheries, University of Washington, 2001, Monitoring And Evaluation Of Smolt Migration In The Columbia Basin Volume IX: Evaluation of the 2001 Redictions of the Run-Timing of Wild and Hatchery-Reared Migrant Salmon and Steelhead Trout Migrating to Lower Granite, Rock Island, McNary, and John Day Dams using Program RealTime, Technical 2001, Report to Bonneville Power Administration, Contract No. 00004134, Project No. 199105100, 130 electronic pages (BPA Report DOE/BP-00004134-1)

This report and other BPA Fish and Wildlife Publications are available on the Internet at:

http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi

For other information on electronic documents or other printed media, contact or write to:

Bonneville Power Administration
Environment, Fish and Wildlife Division
P.O. Box 3621
905 N.E. 11th Avenue
Portland, OR 97208-3621

Please include title, author, and DOE/BP number in the request.

MONITORING AND EVALUATION OF SMOLT MIGRATION IN THE COLUMBIA BASIN

VOLUME IX

Evaluation of the 2001 Predictions of the Run-Timing of Wild and Hatchery-Reared Migrant Salmon and Steelhead Trout migrating to Lower Granite, Rock Island, McNary, and John Day Dams using Program RealTime

Prepared by:

Caitlin Burgess
John R. Skalski

School of Fisheries
University of Washington
1325 Fourth Avenue, Suite 1820
Seattle, Washington 98101-2509

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number 1991-051-00
Contract Number 00004134

December 2001

Other Publications in this Series

Volume I: Townsend, R. L., J. R. Skalski, and D. Yasuda. 1997. Evaluation of the 1995 predictions of run-timing of wild migrant subyearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-35885-11) to BPA, Project 91-051-00, Contract 91-BI-91572.

Volume II: Townsend, R. L., J. R. Skalski, and D. Yasuda. 1998. Evaluation of the 1996 predictions of run-timing of wild migrant subyearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-91572-2) to BPA, Project 91-051-00, Contract 91-BI-91572.

Volume III: Townsend, R. L., J. R. Skalski, and D. Yasuda. 2000. Evaluation of the 1997 predictions of run-timing of wild migrant yearling and subyearling chinook and sockeye in the Snake River Basin using program RealTime. Technical Report to BPA, Project 91-051-00, Contract 91-BI-91572.

Volume IV: Burgess,C., R. L. Townsend, J.R. Skalski, and D. Yasuda. 2000. Evaluation of the 1998 predictions of the run-timing of wild migrant yearling and subyearling chinook and steelhead, and hatchery sockeye in the Snake River Basin using program RealTime. Technical Report to BPA, Project 91-051-00, Contract 96BI-91572.

Volume V: Burgess,C., J.R. Skalski. 2000. Evaluation of the 1999 predictions of the run-timing of wild migrant yearling and subyearling chinook salmon and steelhead trout, and hatchery sockeye salmon in the Snake River Basin using program RealTime. Technical Report to BPA, Project 91-051-00, Contract 96BI-91572.

Volume VI: Burgess,C., J.R. Skalski. 2000. Evaluation of the 2000 predictions of the run-timing of wild migrant chinook salmon and steelhead trout, and hatchery sockeye salmon in the Snake River Basin, and combined wild and hatchery salmonids migrating to Rock Island and McNary Dams using program RealTime. Technical Report to BPA, Project 91-051-00, Contract 96BI-91572.

Volume VII: Skalski, J.R. and R.F. Ngouenet. 2001. Evaluation of the Compliance Testing Framework for RPA Improvement as Stated in the 2000 Federal Columbia River Power System (FCRPS) Biological Opinion. Technical Report to BPA, Project 91-051-00, Contract 96BI-91572.

Volume VIII: Skalski, J.R. and R.F. Ngouenet. 2001. Comparison of the RPA testing rules provided in the 2000 Federal Columbia River Power System (FCRPS) Biological Opinion with new test criteria designed to improve the statistical power of the biological assessments. Technical Report to BPA, Project 91-051-00, Contract 96BI-91572.

Volume IX: Burgess,C., J.R. Skalski. 2001. Evaluation of the 2001 Predictions of the Run-Timing of Wild and Hatchery-Reared Migrant Salmon and Steelhead Trout migrating to Lower Granite, Rock Island, McNary, and John Day Dams using Program RealTime. Technical Report to BPA, Project 91-051-00, Contract 96BI-91572.

Other Publications Related to this Series

Other related publications, reports and papers available through the professional literature or from the Bonneville Power Administration (BPA) Public Information Center - CKPS-1, P.O. Box 3621, Portland, OR 97208.

1997

Townsend, R. L., D. Yasuda, and J. R. Skalski. 1997. Evaluation of the 1996 predictions of run timing of wild migrant spring/summer yearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-91572-1) to BPA, Project 91-051-00, Contract 91-BI-91572.

1996

Townsend, R. L., P. Westhagen, D. Yasuda, J. R. Skalski, and K. Ryding. 1996. Evaluation of the 1995 predictions of run timing of wild migrant spring/summer yearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-35885-9) to BPA, Project 91-051-00, Contract 87-BI-35885.

1995

Townsend, R. L., P. Westhagen, D. Yasuda, and J. R. Skalski. 1995. Evaluation of the 1994 predictions of the run-timing of wild migrant yearling chinook in the Snake River Basin. Technical Report (DOE/BP-35885-8) to BPA, Project 91-051-00, Contract 87-BI-35885.

1994

Skalski, J. R., G. Tartakovsky, S. G. Smith, P. Westhagen, and A. E. Giorgi. 1994. Pre-1994 season projection of run-timing capabilities using PIT-tag databases. Technical Report (DOE/BP-35885-7) to BPA, Project 91-051-00, Contract 87-BI-35885.

1993

Skalski, J. R., and A. E. Giorgi. 1993. A plan for estimating smolt travel time and survival in the Snake and Columbia Rivers. Technical Report (DOE/BP-35885-3) to BPA, Project 91-051-00, Contract 87-BI-35885.

Smith, S. G., J. R. Skalski, and A. E. Giorgi. 1993. Statistical evaluation of travel time estimation based on data from freeze-branded chinook salmon on the Snake River, 1982-1990. Technical Report (DOE/BP-35885-4) to BPA, Project 91-051-00, Contract 87-BI-35885.

Preface

Project 91-051 was initiated in response to the Endangered Species Act (ESA) and the subsequent 1994 Council Fish and Wildlife Program (FWP) call for regional analytical methods for monitoring and evaluation. This project supports the need to have the "best available" scientific information accessible to the BPA, fisheries community, decision-makers, and public by analyzing historical tagging data to investigate smolt outmigration dynamics, salmonid life histories and productivity, and providing real-time analysis to monitor outmigration timing for use in water management and fish operations of the hydrosystem. Primary objectives and management implications of this project include: (1) to address the need for further synthesis of historical tagging and other biological information to improve understanding and identify future research and analysis needs; (2) to assist in the development of improved monitoring capabilities, statistical methodologies and software tools to aid management in optimizing operational and fish passage strategies to maximize the protection and survival of listed threatened and endangered Snake River salmon populations and other listed and nonlisted stocks in the Columbia River Basin; (3) to design better analysis tools for evaluation programs; and (4) to provide statistical support to the Bonneville Power Administration and the Northwest fisheries community.

The following report addresses measure 4.3C of the 1994 Northwest Power Planning Council's Fish and Wildlife Program with emphasis on improved monitoring and evaluation of smolt migration in the Columbia River Basin. This report represents the eleventh in a series of technical reports presenting results of applications of statistical program RealTime to present in-season predictions of the status of smolt migrations in the Columbia River Basin. Results and evaluation of program RealTime 2001 predictions of the run-timing of wild and hatchery-reared salmon and steelhead trout to Lower Granite, Rock Island, McNary, and John Day dams are presented. It is hoped that making these real-time predictions and supporting data available on the Internet for use by the Technical Management Team (TMT) and members of the fisheries community will contribute to effective in-season population monitoring and assist in-season management of river and fisheries resources. Having the capability to more accurately predict smolt outmigration status improves the ability to match flow augmentation to the migration timing of ESA listed and other salmonid stocks and also contributes to the regional goal of increasing juvenile passage survival through the Columbia River system.

ABSTRACT

Program RealTime provided tracking and forecasting of the 2001 inseason outmigration via the internet for eighteen PIT-tagged stocks of wild salmon and steelhead to Lower Granite and/or McNary dams and eleven passage-indexed stocks to Rock Island, McNary, or John Day dams. Nine of the PIT-tagged stocks tracked this year were new to the project. Thirteen ESUs of wild subyearling and yearling chinook salmon and steelhead, and one ESU of hatchery-reared sockeye salmon were tracked and forecasted to Lower Granite Dam. Eight wild ESUs of subyearling and yearling chinook salmon, sockeye salmon and steelhead were tracked to McNary Dam for the first time this year. Wild PIT-tagged ESUs tracked to Lower Granite Dam included yearling spring/summer chinook salmon release-recovery stocks (from Bear Valley Creek, Catherine Creek, Herd Creek, Imnaha River, Johnson Creek, Lostine River, Minam River, South Fork Salmon River, Secesh River, and Valley Creek), PIT-tagged wild runs-at-large of yearling chinook salmon and steelhead, and a PIT-tagged stock of subyearling fall chinook salmon. The stock of hatchery-reared PIT-tagged summer-run sockeye salmon smolts outmigrating to Lower Granite Dam, consisted this year of a new stock of fish from Alturas Lake Creek, Redfish Lake Creek Trap and Sawtooth Trap. The passage-indexed stocks, counted using FPC passage indices, included combined wild- and hatchery-reared runs-at-large of subyearling and yearling chinook, coho, and sockeye salmon, and steelhead migrating to Rock Island and McNary dams, and, new this year, combined wild and hatchery subyearling chinook salmon to John Day Dam.

Unusual run-timing and fish passage characteristics were observed in this low-flow, negligible-spill migration year. The period for the middle 80% of fish passage (i.e., progress from the 10th to the 90th percentiles) was unusually short for nine out of ten PIT-tagged yearling spring/summer chinook salmon stocks tracked to Lower Granite Dam. It was the shortest on record for seven of these ten stocks. The nine stocks recording unusually short middle 80% periods also recorded higher-than-average recovery percentages. However the opposite trend was observed for the PIT-tagged wild subyearling chinook salmon and hatchery sockeye salmon stocks whose middle 80% period of passage to Lower Granite Dam was average to above average. Recovery percentages for these two stocks were average, compared to historical recoveries.

The performance results of Program RealTime to make accurate predictions of percentiles of fish passage at an index site were mixed this year. The release-recovery stocks of wild PIT-tagged

spring/summer chinook salmon tracked to Lower Granite Dam were predicted less accurately than usual, on average, with two exceptions. One of these exceptions was a stock that had its best prediction (first-half, last-half, and season-wide) ever to occur. On average, however, performance was down for predicting these stocks. The RealTime Select composite season-wide MAD was 4.3%, larger than the historical average of 2.1%.

Passage percentiles for PIT-tagged runs-at-large of wild Snake River yearling and subyearling chinook salmon and of wild steelhead outmigrating to Lower Granite Dam were predicted very well this year, their second year of inclusion in the project, with season-wide MADs of 3.6%, 4.7%, and 1.8% respectively. These results, too, were mixed with respect to comparison with last year's performance. The yearling chinook stock was predicted somewhat better last year (up from 1.7% last year to 3.6% this year) but the subyearling chinook salmon and steelhead stocks were predicted better this year than last, season-wide. The steelhead stock, in particular, was predicted much better this year than last year, down to 1.8% this year from 4.8% last year. The PIT-tagged runs-at-large of wild salmon and steelhead tracked to McNary Dam in 2001 for the first time, were also well-predicted. In particular, the Snake River stocks were well-predicted, with season-wide MADs of 4.7% for subyearling chinook salmon, 3.3% for yearling chinook salmon, and 1.4% for steelhead. All three Snake River stocks were better predicted at McNary Dam than they were at Lower Granite Dam. The Upper Columbia River PIT-tagged runs-at-large of wild subyearling chinook salmon and wild steelhead were not predicted with the remarkable accuracy of the Snake River stocks, but RealTime performance for these stocks was still good, with season-wide MADs of 7.9% and 4.9%, respectively.

The results of RealTime predictions of FPC passage-indexed percentiles of combined wild and hatchery-reared salmonids to Rock Island and McNary dams were comparable to last year with respect to the large variability in performance. Like last year some runs were predicted very well while others were predicted very poorly. The stocks predicted best and worst last year were not necessarily the stocks predicted best and worst this year, however. Coho salmon were predicted extremely well both last year and this, at both dams, for the season-wide performance as well as for the first and last halves of the migration season. But sockeye salmon passage, predicted very poorly to Rock Island Dam last year for the first half of the outmigration (MAD = 19.5%), was very well-predicted this year for the first half at Rock Island (MAD = 3.6%). The best predictions for 2001 were not as good as the best predictions for last year (< 1% last year compared to over 2% this year). However, the worst predictions for 2001 were not as bad as the worst predictions last year (>19% last year compared to under 16% this year). These large differences in performance are likely due to large hatchery releases which disturb normal patterns of fish passage.

Results of comparing predictions made based on similar-flow years versus all historical years were mixed. The wild PIT-tagged run-at-large of yearling chinook salmon tracked to McNary Dam was better-predicted using low-flow years (1992,1994) only, while the reverse was true for subyearling chinook salmon and steelhead.

Executive Summary

2001 Objectives

1. Expand and refine application of program RealTime to include in-season predictions of the run-timing of PIT-tagged runs-at-large of wild subyearling and yearling chinook salmon, sockeye salmon and steelhead to McNary Dam; to include the passage-indexed run-at-large of combined wild and hatchery subyearling chinook salmon at John Day Dam.
2. Continue to predict and report in real-time the “percent run-to-date” and “date to specified percentiles” of the outmigrations to Lower Granite Dam of wild PIT-tagged runs-at-large of yearling chinook salmon and steelhead, and release-recovery stocks of wild PIT-tagged sub-yearling and yearling chinook salmon and hatchery-reared PIT-tagged sockeye salmon; of the outmigration to Rock Island and McNary dams of passage-indexed runs-at-large of combined wild and hatchery subyearling and yearling chinook salmon, coho and sockeye salmon and steelhead based on the Fish Passage Center’s (FPC) passage indices.
3. Post on-line Internet-based predictions on outmigration status and trends to improve in-season population monitoring information available for use by the Technical Management Team and the fisheries community to assist river management.

Accomplishments

Many new runs of salmonids were added to the RealTime project in 2001 in order to provide run-timing and passage information on threatened or endangered stocks in a low-flow year. There were seven new runs of wild PIT-tagged salmonids added to the project this year. These new runs tracked and forecasted outmigrations of wild smolts to McNary Dam for the first time. In addition a run of combined wild and hatchery-reared passage-indexed salmon smolts was tracked by Program RealTime to John Day Dam for the first time.

The RealTime 2001 project tracked and forecasted a total of ten wild PIT-tagged Snake River spring/summer yearling chinook salmon release-recovery stocks. Of these, nine met RealTime’s historical data requirements. These nine include Bear Valley Creek, Catherine Creek, Imnaha River, Johnson Creek, Lostine River, Minam River, South Fork Salmon River, and Secesh River, and Valley Creek. As in previous years, ESUs which did not meet data requirements (Herd Creek) were included in the RealTime project for the dual purpose of providing maximum run-timing information on ESU stocks and continuing to test whether release sites with less data nevertheless provide good predictions. The protocol of releasing unmarked hatchery salmon of all *Oncorhynchus* species into the Snake River has continued since 1999. To provide run-timing information on wild runs-at-large, since 1999, the RealTime forecasting project has tracked and forecasted wild, PIT-tagged subpopulations of subyearling and yearling chinook salmon, and steelhead runs-at-large. In 2001 five new PIT-tagged runs-at-large of wild salmonids were added to the project, to provide similar information on these salmon and steelhead outmigrations to McNary Dam. The objective of providing run-timing forecasts for PIT-tagged hatchery-reared sockeye salmon from the Redfish Lake area in Idaho was accomplished in 2001 by including a new run, a composite of Alturas Lake Creek, Redfish Lake Creek Trap, and Sawtooth Trap fish, to replace the Redfish Lake stock which recorded no releases of PIT-tagged fish for the 2001 outmigration. Passage indices provided by the Fish Passage Center at Rock Island Dam and McNary Dam were utilized by the RealTime project for the second time again in 2001, to forecast the combined wild and hatchery-reared subyearling and yearling chinook, coho, and sockeye salmon, and steelhead runs-at-large. Run-timing forecasts were provided for the first time in 2001 for the passage-indexed run-at-large of subyearling chinook salmon to John Day Dam. On-line run-timing predictions were provided via the Internet at *http://www.cbr.washington.edu/crisprt* to the fisheries community throughout each smolt outmigration.

Spill was negligible at all dams in 2001. During short bursts of spill recorded late in the season, raw counts of PIT-tagged subyearling chinook smolts at Lower Granite Dam were adjusted upward to account for spill using the 2000 formulation. Detections of wild PIT-tagged fish migrating to McNary Dam were adjusted by using a one-to-one formulation for spill.

A calibration procedure, developed for Program RealTime in 2000 to optimize algorithm performance with respect to timing of model utilization was applied to all runs forecasted by Program RealTime in 2001. The calibration procedure was shown to improve prediction performance for many stocks tracked (Burgess and Skalski, 2000a).

Findings

Program RealTime predictive performance in 2001 was mixed. Stocks new to the RealTime project this year were predicted remarkably well. In particular, PIT-tagged runs-at-large of wild Snake River subyearling and yearling chinook salmon, and steelhead were tracked with very good accuracy to McNary Dam (season-wide MADs equal to 4.7%, 3.3% and 1.4%, respectively), superior to that of the similar runs tracked to Lower Granite Dam. On the other hand many stocks with a long history in the project were predicted poorly. The RealTime Select Composite, a measure of overall performance for predictions of wild release-recovery spring/summer yearling chinook salmon stocks tracked to Lower Granite Dam, a stock of long standing in the project, recorded the largest MADs of any year. First-half performance for the ten stocks making up the composite was worse than average, due to larger-than-average detection rates, a phenomenon also observed in 1998. Unlike 1998, which recorded better-than-average last-half performance, 2001 also recorded a worse-than-average last-half performance. The average of the ten season-wide MADs was 7.0% in 2001 compared to the overall average of 3.8% in 2000.

Performance in predicting passage percentiles of the PIT-tagged runs-at-large of wild Snake River subyearling and yearling chinook salmon and steelhead to Lower Granite was very good, with season-wide MADs for these three runs to Lower Granite Dam equal to 4.8%, 3.6% and 1.8%, respectively, very similar to the season-wide MADs for these runs to McNary Dam (4.7%, 3.3% and 1.4% respectively). The PIT-tagged runs-at-large of wild Upper Columbia River subyearling chinook salmon and steelhead tracked to McNary Dam were also predicted well, though not as well as the Snake River runs, with season-wide MADs of 7.9% and 4.9%, respectively. The new run of PIT-tagged wild Snake River sockeye salmon tracked to McNary had a season-wide MAD of 6.0%. PIT-tagged hatchery sockeye salmon from the Redfish Lake area to Lower Granite Dam were forecasted with accuracy comparable to that for other stocks tracked by Program RealTime in previous years from that area (i.e., Redfish Lake and Alturas Lake), with season-wide MAD equal to 6.4%.

The runs-at-large of combined hatchery and wild passage-indexed stocks for subyearling and yearling chinook salmon, coho and sockeye salmon and steelhead to Rock Island and McNary dams were predicted moderately well, with some stocks being better predicted and others not as well as last year. In general the worst predictions in 2001 were better than the worst of 2000, but the best predictions in 2001 were not as good as the best predictions last year. Like last year, there was considerable range in performance, with very good performance evidenced for some stocks (coho salmon to both dams) and poorer performance for others (sockeye salmon to Rock Island Dam). Poor performances for these stocks were probably due, like last year, to large releases of hatchery fish swamping the normal pattern of fish passage. In general the subyearling chinook salmon runs to all dams, including to John Day Dam (a new run) were not predicted as well as the other species of fish, or as well as last year, during this low-flow migration year, the lowest in the course of the RealTime project.

Run-timing characteristics were unusual in 2001 insofar as many stocks (17 out of 21 PIT-tagged stocks) had a shorter-than-average middle 80% passage period, with over a third of these stocks recording the shortest middle 80% period of any year. The concurrent observations of higher-than-average detection rates for yearling chinook salmon stocks, along with the fact of no spill at Lower Granite Dam warrants further study to determine whether low-flow years can be better predicted. Comparisons of passage predictions based on all historical years versus low-flow years (1992, 1994) revealed that yearling chinook salmon stocks were better predicted using low-flow years while subyearling chinook salmon and steelhead were better predicted using all years.

Management Implications

The ability to accurately predict the outmigration status of composite or individual salmon and steelhead stocks at different locations in the Federal Columbia River Power System (FCRPS) can provide valuable information to assist water managers. Since the 1994 outmigration, program RealTime has been applied to provide in-season predictions of smolt outmigration timing for individual and aggregates of listed threatened and endangered Snake River salmon stocks. These predictions have been made available to the fisheries community to assist in-season river management.

Table of Contents

List of Tables

List of Tables (continued)

List of Tables (continued)

List of Tables (continued)

List of Tables (continued)

List of Figures

List of Figures (continued)

Figure **Page**

List of Figures (continued)

Figure **Page**

List of Figures (continued)

List of Figures (continued)

Acknowledgments

We wish to express thanks to the many fisheries agencies, Tribes and other institutions that have expended considerable resources in the generation, assembly, analysis and sharing of Columbia River biological, hydrologic, operational and other related information. Deserving particular thanks are the staff of the agencies and Tribes responsible for conducting the annual Columbia River Smolt Monitoring Program, the Fish Passage Center, and the Pacific States Marine Fisheries Commission PIT-Tag Information System (PTAGIS), primary database centers for providing timely in-season access to fish passage and PIT-tag information; and the University of Washington second-tier database DART (Data Access in Real Time) information system which receives, processes and provides access to biological, hydrologic and operational information via the Internet.

Special appreciation is extended to Chris Van Holmes, Susannah Iltis, and Peter Westhagen, and Rich Townsend of the School of Fisheries at the University of Washington for providing critical technical, data management and computer programming support.

Funding support for this work came from the Pacific Northwest region's electrical ratepayers through the Columbia River Fish and Wildlife Program administered by the Bonneville Power Administration, project number 91-051-00.

1.0 Introduction

Regulating the timing and volume of water released from storage reservoirs (often referred to as flow augmentation) has become a central mitigation strategy for improving downstream migration conditions for juvenile salmonids in the Columbia River Basin. Snake River and Upper Columbia River water managers have used flow augmentation to improve the outmigration survival of stocks listed as threatened or endangered under the Endangered Species Act (ESA). Timing the release of water so that the listed stocks are in place to encounter these augmented flows requires knowledge of the status and trend of the stocks' outmigration timing.

In 1993, work was begun under this project to develop real-time predictions of smolt outmigration dynamics for ESA-listed stocks and other runs-at-large for the Snake and Columbia Rivers. The fruit of this labor was the Program RealTime, a statistical software program which predicts run-timing of individual stocks of salmonids (Skalski et al. 1994). It uses historical data to predict the percentile of the outmigration that will reach an index site, in real-time; and it forecasts the elapsed time until some future percentile is observed at that site. The first in-season predictions were of wild spring/summer chinook salmon smolts from the Snake River drainage above Lower Granite Dam in their 1994 outmigrations. These fish originate in streams listed by the National Marine Fisheries Service (NMFS) as evolutionarily/ecologically significant units (ESUs). As parr, a portion of these fish are annually implanted with passive integrated transponder (PIT, Prentice et al., 1990a, b, c) tags, and released back into their natal streams (Achord et al., 1994, 1995, 1996, 1997, 1998, 2000) where they over-winter until their outmigration as yearlings in the spring and summer. During outmigration, PIT-tag detectors at Lower Granite Dam read the tag codes so individual stocks can be monitored.

University of Washington fisheries scientists subsequently incorporated Program RealTime predictions into their CRiSP model to move the forecasted runs of these stocks down the Snake and Columbia Rivers to McNary Dam (Hayes et al. 1996, Beer et al. 1999, *http://www.cqs.washington.edu/crisprt*).

Since 1994, the RealTime forecasting project has expanded its scope to track and forecast other NMFS-listed populations of Columbia River Basin salmonids. In 1997 Program RealTime began forecasting the run-timing of a stock of hatchery-reared PIT-tagged summer-run sockeye salmon released into remote lakes and streams in Idaho over 700 kilometers upriver from Lower Granite Dam.

The type of data used for these first stocks was release-recapture data, but by 1997, Program RealTime was adapted to utilize simple count data such as Fish Passage Center (FPC) passage indices (e.g., FPC, 1999). New runs using FPC passage indices were included in the 1997 RealTime project to track and provide run-timing forecasts for wild runs-at-large of yearling and subyearling chinook salmon and steelhead to Lower Granite Dam. These runs were predicted with considerable accuracy (Townsend et al. 1998, Burgess et al. 1999) but in 1999 and 2000, new hatchery protocols of releasing unmarked smolts into the Snake River forced discontinuance of these forecasts (Burgess et al., 1999). To continue to provide run-timing information on these runs-at-large, the RealTime project began to track PIT-tagged subpopulations. The first such stock was a release-recapture stock of PIT-tagged wild Snake River subyearling fall chinook salmon. In 2000, RealTime began tracking the PIT-tagged runs-at-large of all wild yearling chinook salmon and steelhead outmigrating to Lower Granite Dam. These runs used simple count data, like FPC passage-indexed runs, except the counts were PIT-detections.

While hatchery releases above Lower Granite make the signature patterns of wild fish impossible to detect, the same is not true for all Columbia River Basin dams. In 2000, the RealTime project began tracking and forecasting runs-at-large of combined hatchery and wild salmon and steelhead to Rock Island Dam on the upper Columbia River and to McNary Dam on the mainstem Columbia. For these forecasts, Program RealTime used FPC passage indices. In 2001, the run-at-large of combined wild and hatchery subyearling fall chinook salmon were tracked and forecasted to John Day Dam on the Columbia River, using FPC passage indices.

Also for the first time in 2001, PIT-tagged runs-at-large of chinook, sockeye, and coho salmon and steelhead were tracked and forecasted to McNary Dam. The many new runs in 2001 reflect concern about water management during a predicted drought year.

This report presents a post-season analysis of Program RealTime performance for 2001. Here we compare RealTime predictions with end-of-season observed distributions of passage indices or PIT detections at Lower Granite, Rock Island, McNary, and John Day dams. During the outmigration season, predictions were accessible daily, via the World Wide Web at address *http://*

www.cqs.washington.edu/crisprt. The website's end-of-season graphical and tabular displays of Program RealTime results, by stock, are included in Appendices A and B of this report. Appendix A contains the daily record of RealTime predictions compared with the season-end observed distributions for all runs tracked by Program RealTime in 2001, and Appendix B contains historical run-timing information for each stock.

2.0 Methods

2.1 Description of Data

2.1.1 PIT-tagged Stocks

PIT-tag data were made available by the Pacific States Marine Fisheries Commission's PIT Tag Information System (PITAGIS) project. In 2001 we tracked and prepared forecasts for 14 PIT-tagged stocks of salmon and steelhead to Lower Granite Dam, and seven stocks of salmon and steelhead to McNary Dam.

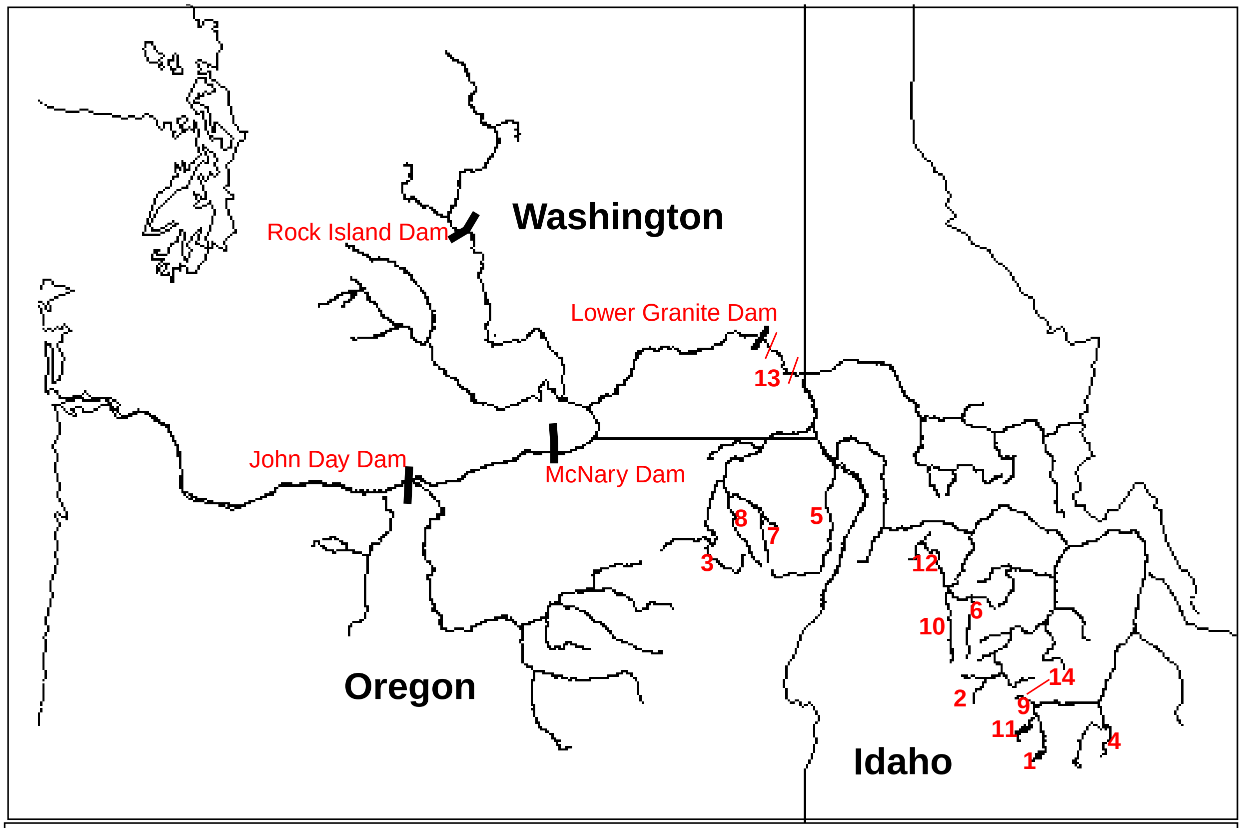
Release-recapture Stocks

The RealTime project provided run-timing information on twelve release-recapture stocks, all tracked to Lower Granite Dam. These were 1) a hatchery-reared, summer-run sockeye salmon composite of fish outmigrating from Alturas Lake Creek, Redfish Lake Creek Trap and Sawtooth Trap (new in 2001), 2) a population of wild subyearling fall chinook salmon PIT-tagged and released into the Snake River near its confluence with the Salmon River (since 1999), and 3) ten stocks of wild spring/summer yearling chinook salmon captured, tagged and released into streams above Lower Granite during the spring, summer and fall of 2000 (since 1995). Figure 2.1 shows the locations of the sites where PIT-tagged smolts from these twelve stocks were released. Table 2.1 displays the U.S. Geological Survey hydrounit numbers for the release sites.

Simple Count Stocks

Two PIT-tagged runs-at-large of wild fish were tracked by Program RealTime to Lower Granite Dam, and seven such aggregates were tracked and forecasted to McNary Dam. The stocks tracked to Lower Granite were 1) all wild PIT-tagged yearling chinook salmon from the Snake River and 2) all wild PIT-tagged steelhead from the Snake River. The stocks tracked to McNary were 1) all wild PIT-tagged subyearling chinook salmon from the Snake River, 2) all wild PIT-tagged subyearling chinook salmon from the Upper Columbia River, 3) all wild PIT-tagged yearling chinook salmon from the Snake River, 4) all wild PIT-tagged sockeye salmon from the Snake River, 5) all wild PIT-tagged steelhead from the Snake River, 6) all wild PIT-tagged steelhead from the Upper Columbia River, 7) all wild PIT-tagged steelhead above McNary Dam.

Figure 2.1: Map showing release sites for PIT-tagged release-recapture stocks (Table 2.1) tracked by Program RealTime in 2001 to Lower Granite Dam.



Release Sites

1. Alturas Lake Creek
2. Bear Valley Creek
3. Catherine Creek
4. Herd Creek
5. Imnaha River
6. Johnson Creek
7. Lostine River
8. Minam River
9. Redfish Lake Trap
10. Salmon R., South Fork
11. Sawtooth Trap
12. Secesh River
13. Snake River, kilometer 224-258
14. Valley Creek

Table 2.1: The GIS hydrounits of PIT-tag/release sites for chinook and sockeye salmon stocks included in the 2001 Program RealTime forecasting project, tracked to Lower Granite Dam.

Release Site					
Abbreviation	Long Name	Rearing	Run	Species	GIS Hydrounit[a]
ALTULC	Alturas Lake Creek	H	Su	Sockeye	17060201
BEARVC	Bear Valley Creek	W	Sp/Su	Chinook	17060205
CATHEC	Catherine Creek	W	Sp/Su	Chinook	17060104
HERDC	Herd Creek	W	Sp/Su	Chinook	17060201
IMNAHR	Imnaha River	W	Sp/Su	Chinook	17060102
JOHNSC	Johnson Creek	W	Sp/Su	Chinook	17060208
LOSTIR	Lostine River	W	Sp/Su	Chinook	17060105
MINAMR	Minam River	W	Sp/Su	Chinook	17060106
RLCTRP	Redfish Lake Creek Trap	H	Su	Sockeye	17060201
SALRSF	Salmon River, South Fork	W	Sp/Su	Chinook	17060208
SAWTRP	Sawtooth Trap	H	Su	Sockeye	17060201
SECESR	Secesh River	W	Sp/Su	Chinook	17060208
SNAKER	Snake River (RK 224 to 268)	W	Fall	Chinook	17060110
VALEYC	Valley Creek	W	Sp/Su	Chinook	17060201

a.Geographical Information System (GIS) designations established by the U.S. Geological Survey.

Data Requirements

Release-recapture stocks have special data requirements that simple count stocks or not. This section lists the requirements for each type of stock.

Spring/summer Yearling Chinook Salmon Release-recapture Stocks

The RealTime 2001 project included ten release-recapture stocks of spring/summer yearling chinook salmon smolts originating from tag/release sites above Lower Granite Dam (Figure 2.1). Each stock constitutes a unique ESU. Originally, tag/release sites were chosen on the basis of their consistent recovery numbers (PIT-detections at LGR)[1], and by virtue of having at least three years of historical data, each with at least 30 PIT-tag detections. Over the years, stocks with less historical information were also forecasted in order to determine whether a lower standard would

1.Detections of PIT-tagged smolts at Lower Granite Dam are seen as recaptures or recoveries in a tag-release-recapture experiment, so the terms “recapture”, “recovery”, and “detection” are used interchangeably.

still provide good predictions. In addition, we forecast “composite runs” which are the combined data from several streams treated as a single stock. The composite runs produce good predictions because they smooth and dampen the randomness of individual stocks. They can be useful for providing general run-timing information for broad geographical regions. Since 1999, the Real-Time project has provided run-timing information and forecasts on three composites. The first, the CRiSP/RealTime composite includes only release sites that meet the extreme data requirements of the CRiSP model. These sites included Catherine Creek, Imnaha River, Minam River, and South Fork Salmon River. The second composite, the RealTime Select Composite, consists of sites that meet the less stringent historical data requirements described above for Program RealTime. In addition to the CRISP/RealTime Composite-stocks, these included Bear Valley Creek, Johnson Creek, Lostine River, Secesh River, and Valley Creek. The third composite, the RealTime All-Stocks composite, include all sites (Figure 2.1, Table 2.1).

Further criteria for choosing yearling chinook stocks ensure representative sampling. Since 1998, the RealTime project has included stocks PIT-tagged by experienced taggers Paul Sankovitch and Steve Achord. Inexperienced taggers may inadvertently bias the sampling. Also, the RealTime project uses detections of fish tagged May 31 - November 1 of the previous year because fish marked later may have different migrational timing characteristics (Keefe et al. 1995, 1996).

Numbers of parr released in 2000 at the sites are displayed in Table 2.2. Historical releases are given in Tables B1-B10 (Appendix B).

Snake River Fall Subyearling Chinook Salmon Stock

Included in 2001 for the third consecutive year, the PIT-tagged subpopulation of PIT-tagged wild fall subyearling chinook salmon is tracked to provide run-timing information about the wild run-at-large of Snake River fall subyearling chinook salmon. Passage indices for the wild run became unavailable after June 6, 1999 (Burgess, et al., 1999). Historical comparisons from 1993 to 1998, of the passage distributions of the run-at-large with the PIT-tagged subpopulation are available at the world-wide website *www.cbr.washington.edu/crisprt/info.html.* Since 1993, William Connor (USFWS at Dworshak Fisheries Complex) has sampled, PIT-tagged and released subyearling fall chinook in the Snake River between river kilometers 224 and 268 as part of doctoral program and ongoing research. The smolts were tagged and released at regular intervals, from April into July or until water temperatures approached 20^{o}C or catches neared zero. These smolts begin to appear at Lower Granite Dam around June 1 and continue through October. The subpopulation mimics the run-at-large passage percentiles well during the first and middle portions of the run. There were 1378 PIT-tagged smolts released for this migration year into the Snake River (Table 2.2). Historical releases are given in Table B13.

Table 2.2: Numbers of releases of PIT-tagged salmon smolts in 2000 (wild spring/summer yearling chinook salmon) or early in 2001 (hatchery sockeye salmon, wild subyearling salmon) at each site[a]. Each site represents a stock tracked and forecasted to Lower Granite Dam by Program RealTime in 2001.

Tagging Location	Number Parr Pit-tagged and Release in 2000
Bear Valley Creek	581
Catherine Creek	501
Herd Creek	311
Imnaha River	1000
Johnson Creek	677
Lostine River	489
Minam River	1000
Salmon River, South Fork	1010
Secesh River	586
Valley Creek	1004
Sockeye for Alturas Lake Creek, Redfish Lake Creek Trap, and Sawtooth Trap	1650
Wild Subyearling Fall Chinook Salmon Tagged and Release between Snake River km 224 and 269	1378

a. Data Sources: PTAGIS and FPC Smolt Index Databases and RealTime program output as of 15 November 2001.

Composite Hatchery Sockeye Salmon Stock

This composite was tracked for the first time in 2001 to replace the Redfish Lake stock which had four years standing in the RealTime project (Townsend et al. 1998, Burgess et al. 1999, Burgess and Skalski 2000a, b). Redfish Lake was not stocked with new hatchery releases in 2000. The 2001 composite consisted of PIT-tagged hatchery-reared summer-run sockeye salmon smolts released after May 1 of 2001 into Alturas Lake Creek, Redfish Lake Creek Trap, and Sawtooth

Trap (Figure 2.1). There were 1650 PIT-tagged smolts released in May of 2001 (Table 2.2). Historical releases are given in Table B12 (Appendix B).

2.1.2 Fish Passage Center (FPC) Passage Index Data

Passage index data were made available by the Northwest Power Planning Council's (NWPPC) Fish Passage Center (FPC). Passage indices are sample counts in the bypass system at the dam divided by the proportion of water passing through the sampling system. They are collected according to FPC sampling plans (e.g., Fish Passage Center, 1999), and are intended to reflect the size of the run.

Runs-at-large of combined wild and hatchery salmonids migrating to Rock Island, McNary, and John Day dams.

Run-timing characteristics of these runs of mid-Columbia and mainstem Columbia River yearling and subyearling chinook salmon, coho and sockeye salmon and steelhead were tracked and forecasted to Rock Island and McNary dams for the second consecutive year in 2001. The runs can be very accurately predicted, provided large hatchery releases to not overwhelm the signature pattern of normal fish passage run-timing (Burgess and Skalski, 2000). New to the project, the run of combined wild and hatchery subyearling fall chinook salmon to John Day Dam was tracked and forecasted for the first time in 2001.

2.2 Preprocessing of Data

Raw PIT-tag count data are adjusted for spill fraction (Section 2.3) and smoothed using three 5-day smoothing passes to filter out statistical randomness, before input to the RealTime forecaster algorithm. Raw passage index data are smoothed the same as PIT-data.

2.3 Adjustment of Raw Smolt Counts for Spill or Flow.

PIT-tag Data

Spillways at hydroelectric projects are low-mortality routes of passage for fish and managers at projects spill water to encourage that route. Fish that pass through the spillway are not detected by PIT-tag interrogation systems, so formulas are used to upwardly adjust the raw counts of PIT-detections. The daily number of fish detected, “raw counts” are multiplied by an expansion factor, resulting in “adjusted counts” according to the formula

raw counts x expansion factor = adjusted counts.

The expansion factor is

$$\frac{1}{1 - SE}, \tag{2.1}$$

where *SE* is *spill effectiveness*, the fraction of smolts passing through the spillway (NMFS, 2000). Different formulations for SE are required for different species of salmonids (Skalski and Perez-Comas 1998) and for different dams configurations (NMFS, 2000). The formula for spill effectiveness for chinook and sockeye salmon is given by Smith et al. (1993) as

$$SE_{chinook,sockeye} = 1.667\left(\frac{S}{F}\right)^3 - 3.25\left(\frac{S}{F}\right)^2 + 2.583\left(\frac{S}{F}\right) \tag{2.2a}$$

(Figure 2.2, red), and the formula for steelhead is given by Skalski and Perez-Comas (1998) as

$$SE_{steelhead} = 0.6001^{\exp\left(-0.5063 \cdot \log\left(\frac{S/F}{1 - S/F}\right)\right)} \tag{2.2b}$$

(Figure 2.2, blue), where S is the daily volume of water spilled and F is daily outflow volume. The 2001 formulation of SE at McNary Dam used by Program RealTime was a one-to-one function (NMFS, 2000) of SE to spill proportion, or volume of water spilled divided by volume of outflow (Figure 2.2, black),

$$SE = \frac{S}{F} = \text{spill volume / flow volume = spill proportion.} \tag{2.2c}$$

Because unusually low flow conditions prevailed in migration year 2001 (Figure 2.3), water managers spilled negligibly (Figure 2.4).

Passage Index Data See Section 2.1.2

Figure 2.2: Spill effectiveness (SE) functions (equations 2.2a, b, c) used by Program Real-Time to upwardly adjust raw PIT-tag detections. Shown are the 2001 RealTime spill effectiveness curves as functions of spill proportion (S/F) at Lower Granite Dam (red, blue) and at McNary Dam (black).

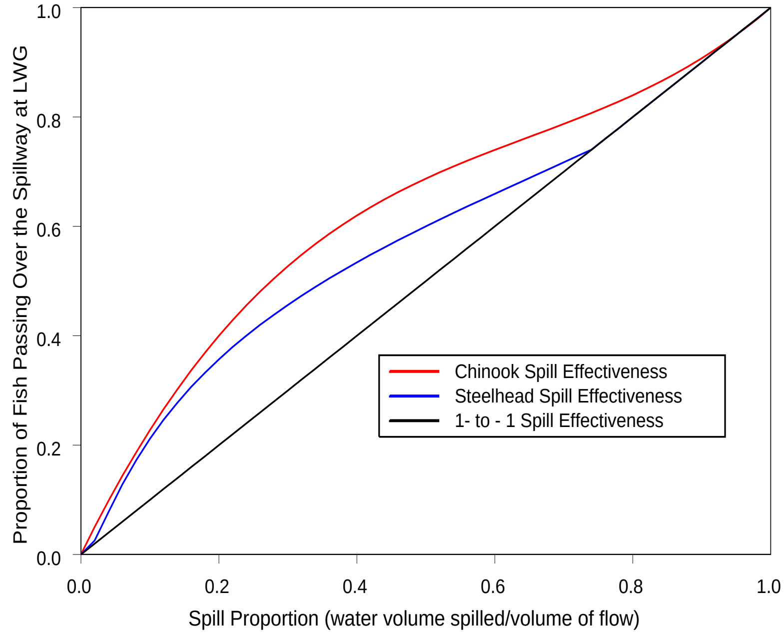


Figure 2.3: Outflow volumes at Lower Granite Dam, April 1-November1, for 1998, 1999, and 2000, 2001. Inseason classification determined 1998 and 2000 were standard flow years and 1999 was a high flow year. Migration year 2001 showed lower-than-average flow.

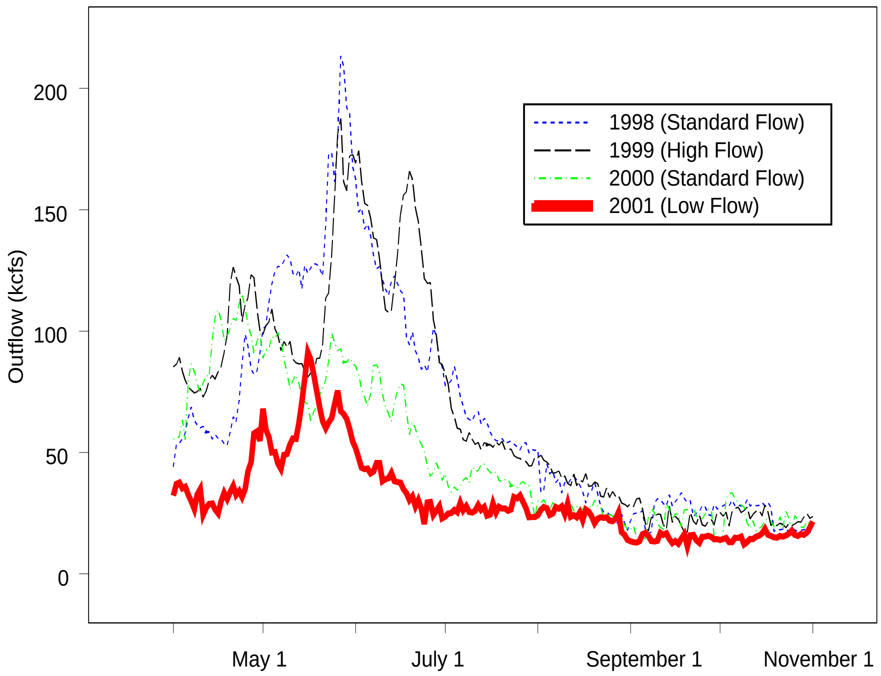
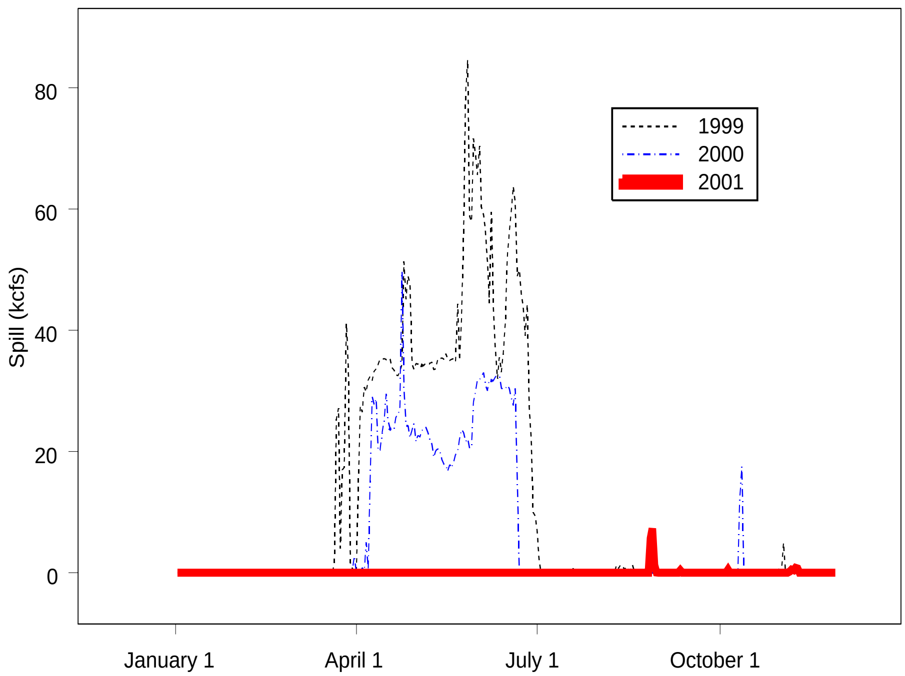


Figure 2.4: Spill in kcfs at Lower Granite Dam for 1999 (high flow), 2000 (standard flow), and 2001 (high flow).



2.4 River Flow

Although it has not been conclusively demonstrated, flow is thought to substantially affect outmigration timing (Connor, et al. 1994b and 1996; Giorgi and Schlechte 1997; Smith et al.1997). Flow is highly correlated with other important river variables, such as turbidity and temperature. Flow surges may influence the numbers of fry that migrate from upriver spawning grounds (Healey, 1991). The 2001 flow year was considered a low-flow year compared to 2000 (standard flow), 1999 (high flow) (Figure 2.3).

2.5 Migration Year 2001

The most noteworthy feature of migration year 2001 was its low volume of outflow in the Snake and Columbia Rivers (e.g., Figure 2.3). One consequence was that negligible water was spilled over dams during the salmonid outmigration, in 2001 (Figure 2.4).

The hatchery practice of releasing unmarked fish into the Snake River, first implemented in 1999 for subyearling fall chinook salmon, was extended to include yearling chinook salmon and steelhead in 2000. Thus, for the second year since 2000, no wild runs-at-large are currently tracked at any Columbia River Basin dam, using passage indices. Smolt numbers are monitored at dams by the Fish Passage Center. FPC passage indices of yearling and subyearling chinook salmon, for coho and sockeye salmon, and for steelhead smolts supply data reflecting the size of the combined wild and hatchery runs. Highly variable releases of hatchery fish obliterate the signature patterns of wild fish passage, making forecasts of wild fish run-timing difficult, particularly Snake River stocks outmigrating to Lower Granite Dam. We continue to provide information about wild runs to Lower Granite and McNary dams by tracking PIT-tagged subpopulations of the runs (Section 2.1.1).

2.6 Models

2.6.1 The RealTime Forecasting Algorithm

The RealTime forecaster is essentially a pattern-matching algorithm. However, at the beginning of the outmigration there is very little in the way of a pattern to match. To optimize predictions for all phases of the outmigration, the forecaster utilizes three models: a start-up model for initial predictions, the pattern-matching model, and a switching model to govern the timing of the switch between the start-up and pattern-matching models.

The pattern-matching portion is accomplished by a least-squares (LS) model, where the patterns are cumulative percentage curves of outmigrating smolts. Current-year data are compared with historical cumulative percentage curves by comparing their slopes at each percentile, $j = 1, \ldots, 100$, using the measure

$$\sum_j (s_j - s_{ijp})^2 \ , \tag{2.3}$$

where s_j is the slope at the j^{th} percentile of current-year data to-date and s_{ijp} is slope at the j^{th} percentile of p percent of historical year i ‘s outmigration. The value of p that minimizes (2.3), i.e.,

$$\min_{p} \left[\sum_{j=1} (s_j - s_{ijp})^2\right], \qquad p = 0, \ldots, 100 \tag{2.4}$$

is the best predictor from the point of view of pattern-matching to historical year i.

The start-up model produces run-percentage (RP) estimates

$$\frac{x_d}{E(\hat{S})}, \tag{2.5}$$

where x_d is the total number of fish observed by day d of the outmigration, and $E(\hat{S})$ estimates the total expected outmigration to Lower Granite Dam. The expectation is estimated differently, depending on the type of data. For tagged stocks for which there is reliable annual release/recapture data (i.e., the twelve release/recovery stocks tracked to Lower Granite Dam, Section 2.1.1), $E(\hat{S})$ is equal to $\bar{r}\ x\ N$, where $\bar{r}$ is the average of the annual historical recapture percentages (annual recapture percentage is the number of detections divided by the number released) at Lower Granite Dam, and N is total releases the previous year for yearling chinook salmon or earlier in the same year (subyearling chinook and sockeye salmon). Tables 2.3 displays N, $\bar{r}$, and $E(\hat{S})$ for each release-recapture stock. For simple count data such as FPC passage indices and PIT-tagged aggregates (Section 2.1.1), $E(\hat{S})$ is the average of historical run sizes. Table 2.4 displays average historical run sizes for each simple count stock.

The RP estimates, (2.5), are more accurate than LS (pattern-matching) estimates (2.4) initially, but are quickly outperformed by LS estimates as the season progresses (Townsend et al., 1995, 1996, 1997).

The switching model is an age-of-run (AR) model based on mean fish run age (MFRA). Thus each model provides a unique own estimate of the true passage percentile. The algorithm selects the best $p = 0, \ldots, 100$ by combining the three (LS, RP, and AR) model estimates, their estimated errors, and two additional switching parameters into a nonlinear combination. The estimated error for the LS model was given in (2.3) above, and the estimated errors for the RP and AR models are, respectively,

$$\left| \log p - \log \hat{RP} \right|, \qquad p = 0, \ldots, 100 \tag{2.6}$$

and

$$\left| \log p - \log \hat{AR} \right|, \quad p = 0, \ldots, 100, \tag{7}$$

where $\hat{RP}$ in (2.6) is the RP model estimator (5) and $\hat{AR}$ in (2.7) is the AR model estimate, based on MFRA. For a complete description of the algorithm's mathematical details, see Burgess, et al., 1999. By including age-of-run (AR) and run percentage (RP) information, the forecaster effectively combines these indicators together with the least-squares (LS) pattern-matching model into a single, more accurate and robust predictor.

Table 2.3: Data used by Program RealTime in 2001 to compute initial predictions (formula 2.5), for PIT-tagged release-recapture stocks of wild Snake River spring/summer yearling chinook salmon, hatchery sockeye salmon, and wild PIT-tagged Snake River subyearling fall chinook salmon[a]. Column (1) is the number, N, of PIT-tagged parr released by site. Column (2) shows historical averages of annual recapture percentage for each site. Column (3) contains expected run sizes for the 2001 migration year.

Tagging Location	(1) Parr PIT-tagged and released, N	(2) Average Historical Recapture Percentage, $\bar{r}$	(3) Expected Run Size, $\hat{E}(S)$
Bear Valley Creek	581	11.6	67
Catherine Creek	501	13.1	66
Herd Creek	311	10.2	32
Imnaha River	1000	12.0	120
Johnson Creek	677	11.7	79
Lostine River	489	15.3	75
Minam River	1000	14.4	144
Salmon River, South Fork	1010	8.6	87
Secesh River	586	10.7	63
Valley Creek	1004	5.7	57
Sockeye for Alturas Lake Creek, Redfish Lake Creek Trap, and Sawtooth Trap	1650	30.8	508
Wild Subyearling Fall Chinook Salmon Tagged and Release between Snake River km 224 and 269	1378	29.1	401

a.Data Sources: PTAGIS Databases and RealTime program output as of 15 November 2001.

Table 2.4: Data used by Program RealTime in 2001 to compute initial predictions (formula 2.5) for simple count stocks. Average historical run sizes[a] of the simple count stocks (runs-at-large) tracked and forecasted by RealTime in 2001. Average historical run sizes are used to predict current year run sizes, $E(\hat{S})$ (Section 2.6.1), which are used to make initial predictions using the run percentage (RP) model.

Rearing	Type of Data	Stock	Passage Predictions made at	Expected 2001 Run Size, $\hat{E}(S)$
Wild	PIT-tag	Spring/Summer Yearling Chinook	Lower Granite Dam	9261
		Steelhead		5865
		Snake River Subyearling Chinook Salmon	McNary Dam	171
		Upper Columbia River Subyearling Chinook Salmon		1657
		Snake River Yearling Chinook Salmon		7156
		Snake River Sockeye Salmon		239
		Snake River Steelhead		2093
		Upper Columbia River Steelhead		1071
		Snake and Upper Columbia River Steelhead		3445
Combined Wild and Hatchery	FPC Passage Indices	Subyearling Chinook Salmon	Rock Island Dam	16897
		Yearling Chinook Salmon		29604
		Coho Salmon		33677
		Sockeye Salmon		15486
		Steelhead		20050
		Subyearling Chinook Salmon	McNary Dam	7771641
		Yearling Chinook Salmon		2169615
		Coho Salmon		334548
		Sockeye Salmon		655423
		Steelhead		722976
		Subyearling Chinook Salmon	John Day Dam	1452962

a.Data Sources: PTAGIS and FPC Smolt Index Databases and RealTime program output as of 15 December 2001.

2.6.2 Precision of Estimator: Confidence Intervals for $\hat{P}$

Each day of the run, a jackknife confidence interval is constructed for the daily prediction estimate, $\hat{P}$ (Section 2.6.1). Jackknifing is a computer-intensive method of extracting sampling distribution information about an estimator by recomputing the estimator from different subsets of the historical data. A jackknife subset consists of the complete set of historical years minus one year. If a release site has, say, six years of historical data, there will be 6 subsets of 5 years each. A prediction is estimated from each subset, and these jackknife predictions provide a measure of dispersion on which the daily confidence interval is based.

2.6.3 Evaluating RealTime Performance

The true outmigration percentile on day d (i.e., P_d) can only be observed after the run is finished (i.e. $P_{last} = 100\%$). When the run is over, we evaluate RealTime's performance using the mean of the absolute differences (MADs) between observed outmigration percentiles, P_d, and their estimates, $\hat{P}_d$, for all days, d:

$$MAD = \frac{\sum_{d=1}^{n} \left|\hat{P}_d - P_d\right|}{n}$$

where n is the total number of days in the outmigration run for the season.

3.0 Results

3.1 Wild ESUs

3.1.1 PIT-tagged Subyearling Chinook Salmon

Release-recapture Stocks Tracked to Lower Granite Dam

The stock of subyearling fall chinook salmon smolts captured, PIT-tagged and released during April through July into the Snake River, near its confluence with the Salmon River (Section 2.1.1) has been tracked by the RealTime project since 1999. The number of days it took for the middle 80% of the outmigration to pass Lower Granite Dam was close to the historical average, but the pattern of fish passage was a little unusual, starting out very slowly and jumping from 12% to 70% in 10 days. The 2001 recovery percentage was smaller than average. The only year since 1993 that recorded a smaller recovery percent was 1994, another low flow year.

RealTime 2001 performance for predicting the passage of this stock was remarkably similar to last year, with the season-wide MAD slightly better at 4.8% than the 2000 MAD of 4.9% (Table 3.1). The 2001 first- and last-half MADs were 3.3% and 5.4%, respectively compared to 3.2% and 5.5% in 2000.

Table 3.1: Mean absolute deviations (MADs) for the 2000 and 2001 outmigrations to Lower Granite Dam, of the PIT-tagged subpopulations of wild Snake River fall subyearling chinook salmon, spring/summer yearling chinook salmon and steelhead. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

Stock	2000			2001		
	Entire Run	First 50%	Last 50%	Entire Run	First 50%	Last 50%
Wild PIT-tagged Fall Subyearling Chinook Salmon released between river kilometers 224 and 268 (SNAKER) and recovered at Lower Granite Dam	4.9	3.2	5.5	4.8	3.3	5.4
All Wild PIT-tagged Snake River Subyearling Chinook Salmon Detected at McNary Dam	---	---	---	4.7	3.7	5.3
All Wild PIT-tagged Upper Columbia River Subyearling Chinook Salmon Detected at McNary Dam	---	---	---	7.9	1.8	10.0
(low-flow run[a])				(10.7)	(8.2)	(11.6)

a. Predictions based on low-flow years 1992 and 1994 only.

Simple-count stocks tracked to McNary Dam

New to the RealTime project, these runs show very different results for the subyearling smolts originating from the Snake River and the Upper Columbia. The Snake River stock was forecast to McNary quite accurately with full-season MAD (4.7%), and first- and last-half MADs (3.7% and 5.3% quite comparable to the stock forecast to Lower Granite. The Snake River run size of 54 was considerably smaller than the expected run size of 171 (Table 2.4), but not the smallest on record. The run-timing characteristics were normal. The Upper Columbia stock of wild subyearling chinook salmon was not well-predicted during the last half (MAD = 16.8%) but was extremely well predicted during the first half of the outmigration. The season-wide MAD was 12.7%, quite large. The number of these smolts detected at McNary in 2001 (1203) was somewhat smaller than expected (1657, Table 2.4) but was relatively close to the historical average.

3.1.2 PIT-tagged Yearling Chinook Salmon

Release-recapture Stocks Tracked to Lower Granite Dam

Table 3.2 shows the mean absolute deviations (MADs, Section 2.6.3) of RealTime predictions for 2001, and comparisons to 2000 MADS where applicable. For comparison of performance with years prior to 2000, see Appendix D. MADs are given for the first and last halves of the outmigration, and for the entire outmigration.

An overall indicator of Program RealTime performance is the set of three MADs for the RealTime Select composite run (Figure 3.1, Table 3.2, see Section 2.1 for definition). The RealTime Select composite-run was predicted with the worst accuracy of any year for the last half of the outmigration (MAD = 4.9%, Table 3.2, and Table D1 in Appendix D) and for the entire run (MAD = 4.3%), both exceeding 3% MAD for the first time in seven years. The RealTime Select Composite for the first half of the outmigration was also predicted with less accuracy than usual (MAD = 3.2%), exceeding 3% for the second time in the seven years of the RealTime project has existed. Figure 3.2 shows the RealTime Select observed distribution (blue) compared with the mean of historical years' passage distributions for this stock (green).

Figure 3.1: Comparison of RealTime daily predictions of fish passage to Lower Granite Dam with the actual year-end distribution of the RealTime Select Composite run (Section 2.1.1), a composite of nine PIT-tagged spring/summer yearling chinook stocks.

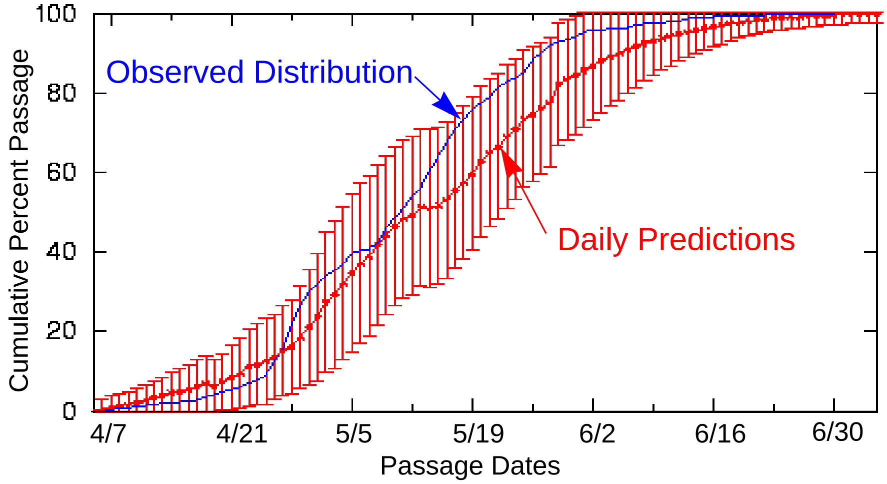


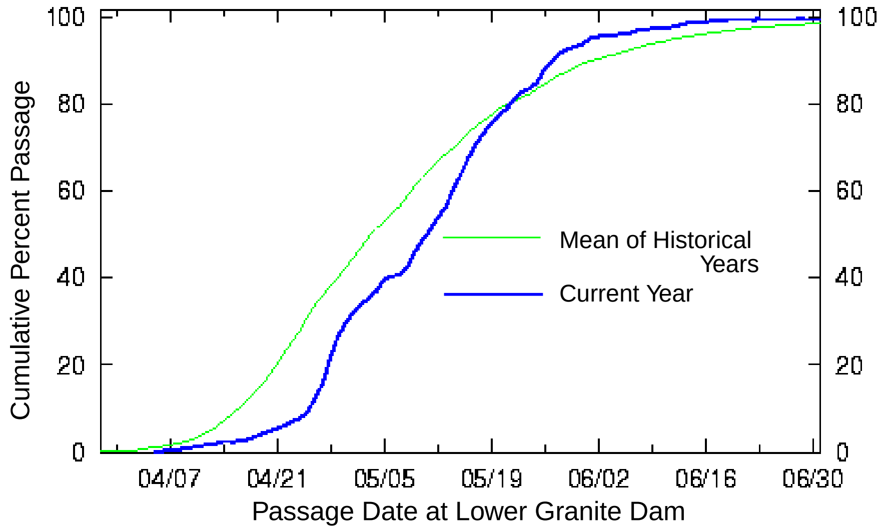
Table 3.2: Mean absolute deviations (MADs, section 2.6.3) for the 2000 and 2001 outmigrations to Lower Granite Dam of 10 wild PIT-tagged Snake River spring/summer yearling chinook salmon ESUs and the RealTime Select Composite runs (section 2.1.1). Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run. Sites in bold are RealTime Select Composite release sites (section 2.1.1).

	2000			2001		
Tagging Site/Stock Name	Entire Run, %	First 50%, %	Last 50%, %	Entire Run, %	First 50%, %	Last 50%, %
Bear Valley Creek	**3.3**	**1.4**	**3.8**	**9.1**	**7.0**	**10.1**
Catherine Creek	**5.2**	**0.8**	**7.6**	**6.5**	**10.0**	**5.4**
Herd Creek	5.8	12.0	4.0	7.7	7.8	7.6
Imnaha River	**2.6**	**3.3**	**2.4**	**5.6**	**5.1**	**5.8**
Johnson Creek	**4.8**	**1.8**	**6.4**	**8.7**	**6.7**	**9.6**
Lostine River	**2.1**	**0.9**	**2.8**	**3.0**	**3.1**	**3.0**
Minam River	**2.2**	**2.8**	**1.9**	**1.6**	**2.1**	**1.3**
Salmon River, South Fork	**2.9**	**1.5**	**3.4**	**5.2**	**4.7**	**5.4**
Secesh River	**3.5**	**5.2**	**3.3**	**12.1**	**19.3**	**9.6**
Valley Creek	**5.5**	**12.9**	**2.9**	**10.3**	**10.1**	**10.4**
mean MAD[a]	3.8	4.3	3.9	7.0	7.6	6.8
median MAD[a]	3.4	2.3	3.4	7.1	6.9	6.7
range[a]	3.7	12.1	5.7	10.6	17.2	9.1
Select Composite Run[b]	**1.1**	**0.8**	**1.2**	**4.3**	**3.2**	**4.9**

a.These statistics are based on all release sites for the given year.

b. Combined data from RealTime Select composite sites, processed by Program RealTime as a single population.

Figure 3.2: Migration year 2001 end-of-season passage distribution of the RealTime Select composite stock (Section 2.1.1) compared with the mean passage distribution of all Select composite historical years[1].



The average MAD for the first half of the 2001 outmigration, averaged over all stocks, was 7.6%, compared to 4.3% in 2000, a 76% increase. There was a 75% increase in last half MAD (averaged over all stocks) and an 84% increase in the season-wide average MAD. Nine of ten stocks had poorer season-wide predictions of run-timing characteristics in 2001 than in 2000. The only stock which was predicted better in 2001 was the Minam River stock, which had a remarkable 2001 season-wide MAD of 1.6%, compared to an already remarkable 2.2% in 2000. The worst performance of RealTime predictions for spring/summer chinook salmon tag/release stocks in 2001 was for the Secesh River, a tributary of the South Fork of the Salmon River. First-half predictions for this stock were quite poor (MAD=19.3%, Figure A5). In 2001, six stocks had season-wide MADs larger than 6%. In 2000, there were none as large as 6%. Catherine Creek smolt passage was predicted with average accuracy for the last half and season-wide, but the first half performance was the worst of any year. Performance in 2001 for Imnaha River and Salmon River, South Fork was average. Lostine River passage was predicted better than average. Smolt passage for both Bear Valley Creek and Valley Creek was predicted with the least accuracy of any year

1. The comparisons of current-year passage with the mean of historical years is a new website feature in 2001 and is available for all RealTime stock by going to the “cumulative graph” page for a stock of interest and selecting the desired options. The “cumulative graph” pages are available for all RealTime stocks from the world-wide website *http://www.cbr.washington.edu/crisprt.*

for the last-half and season-wide.

The range from smallest to largest MADs recorded for these stocks, compared to 2000 shows that there was considerably more variability in RealTime performance this year than last year. That is, some stocks were very well-predicted and others very poorly predicted. Table 3.3 shows dates of first and last PIT-detections per stock for the 2001 outmigration, compared with the historical averages of these dates. Some stocks started later, some earlier than the historical first detection, no pattern emerges and the same is true of final detection date. There is, however, a clear pattern in the comparison of historical and current-year dates marking the tenth and fiftieth percentiles of passage at Lower Granite Dam (Table 3.3). All ten stocks accumulated ten percent passage later than the average historical date. All ten accumulated fifty percent passage at least as late as historically (two were the same). No clear pattern is discernible with respect to the ninetieth percentile.

A commonly used run-timing statistic is the number of days between the tenth and ninetieth percentiles of passage past an index point. This period is called the “middle 80%” of the run. Table 3.4 compares average historical with current-year middle 80% periods, for the ten wild spring/summer yearling chinook stocks outmigrating to Lower Granite Dam. All stocks except Catherine Creek had a shorter middle 80% passage in 2001, compared to historical averages. Interestingly, all stocks except Catherine Creek recorded larger recovery percents in 2001 than historically. That is, a higher-than-average percentage of detections of the PIT-tagged smolts were observed this year, except for Catherine Creek.

Figure 3.3 presents passage percentiles for the yearling chinook and sockeye release-recapture stocks (Section 2.1.1) as a function of distance from Lower Granite Dam. There is a trend of later passage with greater distance from the dam.

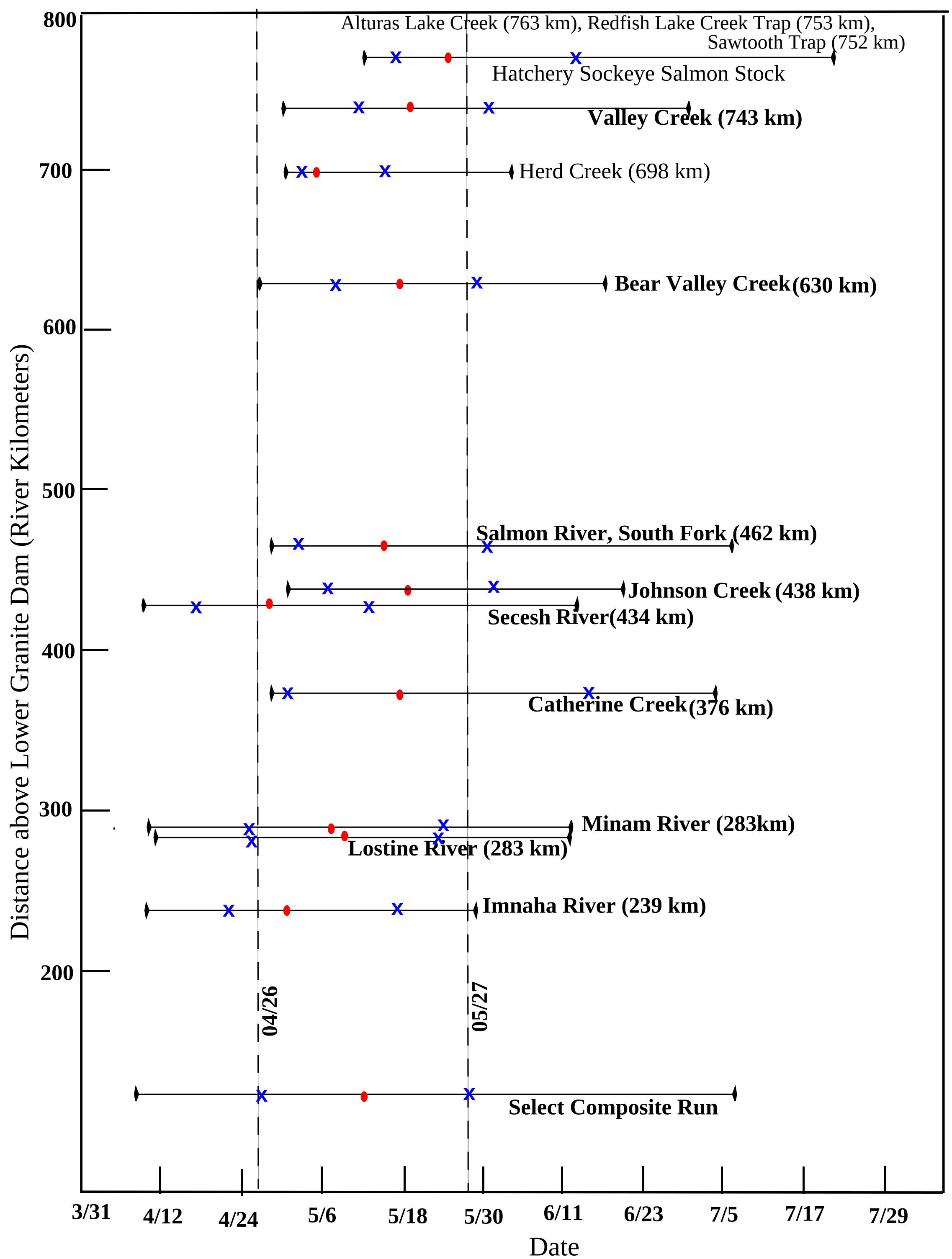
Table 3.3: Dates of first and last detections and of the tenth, fiftieth and ninetieth percentiles of passage through Lower Granite Dam, of ten stocks of PIT-tagged spring/ summer chinook salmon outmigrating in 2001.

Stock Name	Time Period	First Detection	Last Detection	10%	50%	90%
Bear Valley Creek	2001	04/26	06/17	05/08	05/17	05/28
	Historical Average	04/14	07/03	04/25	05/09	06/05
Catherine Creek	2001	04/28	07/03	05/01	05/17	06/15
	Historical Average	04/18	06/22	04/28	05/13	05/31
Herd Creek	2001	04/28	06/07	04/30	05/04	05/14
	Historical Average	04/12	05/24	04/19	04/28	05/12
Imnaha River	2001	04/08	05/28	04/21	04/30	05/16
	Historical Average	04/09	06/11	04/16	04/30	05/18
Johnson Creek	2001	04/28	06/19	05/06	05/18	05/31
	Historical Average	04/17	06/22	04/27	05/15	06/04
Lostine River	2001	04/10	06/12	04/25	05/09	05/22
	Historical Average	04/11	06/03	04/18	05/03	05/21
Minam River	2001	04/08	06/12	04/25	05/07	05/23
	Historical Average	04/08	06/09	04/15	04/30	05/16
Salmon River, South Fork	2001	04/26	07/07	04/29	05/14	06/01
	Historical Average	04/12	07/07	04/22	05/10	06/08
Secesh River	2001	04/06	06/13	04/16	04/28	05/13
	Historical Average	04/09	07/12	04/15	04/28	06/04
Valley Creek	2001	04/28	07/03	05/10	05/19	06/01
	Historical Average	04/18	06/26	04/26	05/14	06/10
RealTime Select Composite	2001	04/06	07/07	04/26	05/11	05/27
	Historical Average	04/06	07/22	04/18	05/05	05/30

Table 3.4: Comparison of historical and current run-timing characteristics and recovery rates of ten PIT-tagged stocks of wild Snake River spring/summer yearling chinook salmon. "Middle 80%" refers to the number of days between the tenth and ninetieth passage percentiles at Lower Granite Dam. Recovery percent is the ratio of number of detections at Lower Granite Dam to number parr releases at release site the previous year.

Stock Name/Release Site	Year	Middle 80%	Recovery Percent
Bear Valley Creek	2001	21	19.3
	Hist.Avg.	42.1	11.6
Catherine Creek	2001	46	6.6
	Hist.Avg.	34	13.1
Herd Creek	2001	15	21.2
	Hist.Avg.	24.2	10.2
Imnaha River	2001	26	15.9
	Hist.Avg.	33.8	12
Johnson Creek	2001	26	19.8
	Hist.Avg.	39.7	11.7
Lostine River	2001	28	17.8
	Hist.Avg.	33.4	15.3
Minam River	2001	29	17.8
	Hist.Avg.	31.2	14.4
Salmon River, South Fork	2001	34	11.5
	Hist.Avg.	48.1	8.6
Secesh River	2001	28	28.8
	Hist.Avg.	50	10.7
Valley Creek	2001	23	13.4
	Hist.Avg.	46.3	5.7
RealTime Select Composite	2001	32	16.4
	Hist.Avg.	43.6	11

Figure 3.3: Run-timing plots of 2001 passage dates (10%, 90%, blue x's; 50%, red dot; and range, endpoints), at Lower Granite Dam for wild Snake River spring/summer yearling chinook salmon ESUs. Vertical axis gives distance in river kilometers of release sites to Lower Granite Dam. Dashed lines show dates of 10% and 90% passage for the RealTime Select composite run. Sites in bold were included in the Select composite.



Simple-count stock tracked to Lower Granite and McNary Dams

Although RealTime 2001 performance of forecasting to Lower Granite Dam was not as remarkable for this stock as last year, it was still quite good, with season-wide MAD of 3.6% and a last-half MAD of 3.0% (Table 3.5). Figure A8 shows early overprediction and subsequent over-correction by Program RealTime, a typical dynamic of RealTime performance when run size is larger than expected, as it was in 2001, with 18076 PIT-tagged fish detected, the largest number on record for this stock (Table 2.4, Table B11). The middle 80% of this run was the shortest on record (Table B11).

This stock was tracked to McNary for the first time this year. RealTime predictions of run-timing were within 4%, on average, of the observed passage percentile (MAD = 3.3%), with a

Table 3.5: Mean absolute deviations (MADs) for the 2000 and 2001 outmigration to Lower Granite and McNary Dams, of the PIT-tagged population of wild Snake River spring/summer yearling chinook salmon. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

Stock	2000			2001		
	Entire Run	First 50%	Last 50%	Entire Run	First 50%	Last 50%
All Wild PIT-tagged Yearling Chinook Salmon Detected:						
at Lower Granite Dam	1.7	5.0	1.0	3.6	6.0	3.0
at McNary Dam (low-flow run[a])	---	---	---	3.3 (2.3)	4.6 (4.0)	2.9 (1.7)

a. Predictions based on low-flow years 1992 and 1994 only.

first-half MAD of 4.6% and last half of 2.9% (Table 3.5). The pattern of prediction is similar to those made by RealTime for the same stock to Lower Granite Dam, of early overprediction and correction at about 30% passage (Figure A10). The middle 80% passage period was the shortest on record to McNary (Table B16). The number of detections at McNary in 2001 was less than half the number of detections recorded in 2000.

To check the effect on RealTime performance of using only similar-flow years to make predictions, a “low-flow” run was included (Figure A10). Predictions were made from historical years 1992 and 1994 only. RealTime performance for this stock, first-half, last-half and full-run, is 4.0%, 1.7% and 2.3% MADs, respectively, represent reductions in predictive error of 13%, 41%, and 30%, respectively.

3.1.3 PIT-tagged Sockeye Salmon

This simple-count stock of Snake River fish was tracked to McNary Dam for the first time this year. It has never been tracked to Lower Granite Dam. Only 38 fish were detected (Table B18), much smaller than the expected 239 smolts for this run (Table 2.4) and the MADs were 6.0% for the full-run (Table 3.6) and 8.2% and 5.6% for the first and last halves of the run. This stock shows very high variability in middle 80% passage timing (Table B18, Figure B18). The length of the middle 80% of the run for 2001 was about in the middle of the range (Table B18).

Table 3.6: Mean absolute deviations (MADs) for the 2001 outmigration to Lower Granite and McNary Dams, of the PIT-tagged population of wild Snake River sockeye salmon. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

	2001		
Stock	Entire Run	First 50%	Last 50%
All Wild PIT-tagged Sockeye Salmon Detected at Lower Granite Dam	6.0%	8.2%	5.6%

3.1.4 PIT-tagged Steelhead Trout

Simple-count stock of Snake River Steelhead Tracked to Lower Granite and McNary Dams

This stock of all wild PIT-tagged Snake River steelhead, now in its second year of being tracked to Lower Granite Dam, was remarkably well-predicted in 2001, with a season-wide MAD of 1.8% (Table 3.7). The first half MAD was 2.7% in 2001 compared to 10.8% in 2000. The large predictive error in 2000 was likely due to the fact that 2000 had the largest number of detections on record, more than twice the historical average, explaining the large first-half overprediction (Burgess et al., 2000, Burgess and Skalski, 2000). Last-half performance was 1.6%, a slight improvement over last year's performance of 2.8%. This stock had an unusually large number of detections in 2001, close to that of 2000. Early overprediction was corrected sharply at about 30% passage. The middle 80% passage period for this stock was shorter than average (Table B16).

RealTime predictions for this stock forecast to McNary Dam were also extremely good, with a season-wide MAD of 1.4% (Table 3.7). The middle 80% period for this stock in 2001 was the shortest on record (Table B17). The PIT-tagged run-at-large of Upper Columbia wild steelhead was not predicted as well as the Snake River run. The first-half MAD was 8.0%, but the last-half MAD of 3.2% brought the season-wide MAD down to 4.9%, a fairly good performance. The combined Upper Columbia and Snake River steelhead run was very-well predicted with a season-wide MAD of 2.3% (Table 3.7). Predictions based on low-flow years were not as good as predictions based on all historical years for the steelhead stocks (Table 3.7). Low-flow first-half MAD was 7.6% compared to 1.6% for the all-year prediction of Snake River steelhead. For the Upper Columbia run, the first-half prediction based on low-flow years was 20.6% compared to 8.0% for the all-year prediction.

Table 3.7: Mean absolute deviations (MADs) for the 2000 and 2001 outmigrations to Lower Granite Dam, of the PIT-tagged subpopulations of wild Snake River fall subyearling chinook salmon, spring/summer yearling chinook salmon and steelhead. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

	2000			2001		
Stock	Entire Run	First 50%	Last 50%	Entire Run	First 50%	Last 50%
All Wild PIT-tagged Snake River Steelhead Detected at Lower Granite Dam	4.8	10.8	2.8	1.8	2.7	1.6
All Wild PIT-tagged Snake River Steelhead Detected at McNary Dam	---	---	---	1.4	1.6	1.4
(Predictions based on low flow years)				(3.0)	(7.6)	(1.6)
All Wild PIT-tagged Upper Columbia River Steelhead Detected at McNary Dam	---	---	---	4.9	8.0	3.2
(Predictions based on low flow years)				(10.0)	(20.6)	(4.1)
All Wild PIT-tagged Steelhead Detected at McNary Dam	---	---	---	2.3	3.2	2.0
(Predictions based on low flow years)				(3.0)	(6.7)	(2.0)

3.2 Hatchery-reared ESUs

The only hatchery-reared PIT-tagged stock tracked by Program RealTime in 2001 was a composite of smolts released into Alturas Lake Creek, Redfish Lake Creek Trap and Sawtooth Trap. This stock, tracked for the first time in 2001, was meant to provide run-timing information on the Redfish Lake Stock, tracked by RealTime from 1997 to 2000. The stock could not be tracked this year because there were not releases in 2000. Predictions were within 7% (MAD = 6.4%), on average over the season (Table 3.8). The run was better predicted during the first half of the outmigration (MAD = 5.5%) than during the last half (MAD = 11.3%). This stock had a longer-than-average middle 80% period of passage, the longest on record.

Table 3.8: Mean absolute deviations (MADs, section 2.6.3) for the 2001 outmigrations to Lower Granite Dam of the PIT-tagged hatchery-reared composite stock from Alturas Lake Creek, and Redfish Lake Trap and Sawtooth Trap. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

Run	2001		
	Entire Run	First 50%	First 50%
Composite Sockeye Run	6.4	11.3	5.5

3.3 Combined Wild and Hatchery Runs-At-Large

The runs-at-large of combined wild and hatchery-reared stocks for yearling and subyearling chinook salmon, coho and sockeye salmon, and steelhead to Rock Island Dam on the Mid-Columbia River and to McNary Dam on the Columbia River (Figures A14-A19, Appendix A) were included in the RealTime forecasting project for the second time in 2001. Because of water management challenges associated with the low-flow conditions of 2001, there was, additionally, an interest in the run of fall subyearling passage-indexed combined wild and hatchery run to John Day Dam, and the RealTime project included this run for the first time in 2001. The MADs for these runs in 2001 are shown in Table 3.9. In general, the largest MADs are probably explained by large, sudden hatchery releases which caused the characteristic smoothly accumulating patterns of fish passage to be disturbed by large discontinuities, with large releases early in the outmigration probably having the most pronounced effects.

The new run of subyearling chinook salmon tracked to John Day Dam was predicted poorly during the first half of the season (16.0%) but moderately well for the last half of the season (4.4%). This was the reverse of results for subyearling chinook observed at Rock Island and McNary dams. Subyearling chinook passage was predicted less well in 2001 than in 2001 at both Rock Island Dam and McNary Dam. The 2001 season-wide MADs were 9.1% and 6.3% at the two dams, respectively, compared to 2.9% and 1.6% in 2000. Last-half MADs for these runs saw particularly large increases relative to last year (the last-half MAD at Rock Island Dam was 10.8% in 2001, compared to 1.9 in 2000; the last-half MAD at McNary Dam was 6.6% in 2001, compared to 1.3% in 2000).

Table 3.9: Mean absolute deviances (MADs, section 2.6.3) for the 2000 and 2001 outmigrations to Rock Island, McNary, and John Day dams of FPC passage indices of the combined wild and hatchery runs-at-large of salmon and steelhead. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

Run-of-Year	2000			2001			Tracked and Forecast to
	Entire Run	First 50%	Last 50%	Entire Run	First 50%	Last 50%	
Subyearling Chinook Salmon	2.90	3.97	1.94	9.1	6.8	10.8	Rock Island Dam
Yearling Chinook Salmon	5.04	15.70	1.76	7.7	13.5	5.8	
Coho Salmon	1.04	1.77	0.50	3.7	5.6	3.2	
Sockeye Salmon	16.96	19.45	16.23	12.8	3.6	15.9	
Steelhead	4.47	10.83	2.07	4.1	9.7	1.3	
Subyearling Chinook Salmon	1.57	3.43	1.25	6.3	4.9	6.6	McNary Dam
Yearling Chinook Salmon	0.59	0.71	0.55	5.70	1.21	7.12	
Coho Salmon	0.72	0.88	0.66	2.55	2.84	2.43	
Sockeye Salmon	9.47	12.73	8.66	8.52	1.47	10.92	
Steelhead	2.85	3.80	2.68	9.36	15.14	7.69	
Subyearling Chinook Salmon	---	---	---	10.0	16.0	4.4	John Day Dam

Season-wide predictions for coho salmon were the best of all the runs, at both dams in 2001 and in 2000. In 2000, the sockeye salmon runs were the worst of all the runs for the first half of the season at both dams (19.5% at Rock Island and 12.7% at McNary Dam). In 2001, the first half of the sockeye salmon run was the best-predicted of any first-half run at Rock Island Dam (3.6%) and the second-best- predicted of any at McNary Dam (1.5%). Last-half MADs for the sockeye salmon run, were however, the largest of all the stocks at both dams, and were comparable to 2000 last-half performance. Yearling chinook salmon passage was extraordinarily well-predicted at McNary in 2000, and was moderately well-predicted at McNary in 2001, with a season-wide MAD of 6.3%. First-half predictions of yearling chinook passage at Rock Island Dam were poor both years (13.5% in 2001), but good to moderate for the last-half of the runs (5.8% in 2001). Steelhead passage prediction improved at Rock Island Dam in 2001 somewhat. Season-wide MAD for 2001 was 4.1%. Predictions of steelhead passage were somewhat poor at McNary Dam, in particular during the first half of the season, with a MAD of 15.14%.

4.0 Discussion

For the first time in four years, there were fewer wild spring/summer yearling chinook salmon release-recapture stocks than the previous year, a result of decreased PIT-tagging of parr in 2000. In 2000 there were nineteen such stocks tracked and forecasted by Program RealTime to Lower Granite Dam, compared to ten in 2001. These 10 included two from the Grande Ronde and eight from the Salmon River tributaries of the Snake River. Nine of the sites met the RealTime data requirements of historical releases and observations (section 2.1.1). On average, RealTime performance for these stocks was not as good as it was in 2000. The average of ten stocks' season-wide MADs was 7.0% in 2001, compared to 3.8% in 2000. Even so, two stocks were very well-predicted. Minam River recorded the best predictions of any year and Lostine River had smaller-than-average predictive error. In addition, RealTime performance in 2001 for these stocks compared unfavorably to historical performance, results which are coeval with the lowest river-flow measurements in the course of the RealTime project. Run-timing characteristics for these stocks show a clear pattern of later-than-average 10th and 50th percentile passage past Lower Granite Dam. Coupled with normal 90th percentile passage, this resulted in shorter-than-average middle 80% periods of passage. Another clear pattern, of larger-than-average recovery percentages (i.e.

number PIT-tagged fish observed relative to the number released), was observed in 2001. These two patterns were observed for all stocks (except Catherine Creek) are are likely due to low spill volumes in 2001.

The higher-than-average recovery percent seen in the yearling chinook release-recapture stocks is reminiscent of a similar trend observed for the 1998 migration year, which saw initial overprediction for every spring/summer yearling chinook salmon release-recapture stock. This trend in overprediction can be traced to the dynamics of the RealTime algorithm's start-up model (see Burgess et al., 1999 for complete explanation). In 2001, large first-half MADs are explained the same way. The similarity with 1998 ends there however, as last-half MADs in 1998 were better than average, whereas in 2001 last-half MADs were larger than average also. Unexpected surges fish at the end of the most of these runs resulted in large underprediction in the last half of the season (Figures 3.1 and A1-A6, Appendix A).

The composite stock of hatchery-reared sockeye salmon from the Redfish Lake area was a new stock in the RealTime project this year, but RealTime performance was similar to that for the Redfish Lake stock, tracked to Lower Granite Dam 1997-2000 (Burgess and Skalski 2000a and b, Burgess et al., 1999, Townsend et al., 2000), in season-wide performance (MAD = 6.4%) and in the fact that this stock displays similar large variability in historical run-timing characteristics and percent recoveries.

The 2001 migration year is the first year the RealTime project has tracked wild PIT-tagged ESUs of salmonids to McNary Dam. Included to help water managers make policy in a low-flow year, these represent the entire fish-mitigation efforts of PIT-tagging wild threatened or endangered salmonids in the Snake and Upper Columbia River drainages for chinook and sockeye salmon, and steelhead. Wild PIT-tagged Snake River subyearling chinook salmon tracked to McNary Dam were well-predicted with season-wide MAD (4.7%) very similar to that for the subyearling run tracked to Lower Granite Dam (MAD = 4.8%). The PIT-tagged run-at-large of wild Snake River yearling chinook smolts was very well-predicted to both dams (MAD for the run to Lower Granite was 3.6%; MAD for the run to McNary was 3.3%), and runs to both dams had similar passage characteristics. The PIT-tagged wild run-at-large of Snake River steelhead was extremely well-predicted to both Lower Granite and McNary dams (season-wide MADs were 1.8% and 1.4%, respectively) and both runs had similar run-timing characteristics. The run of PIT-tagged wild Snake River sockeye salmon tracked to McNary Dan was fairly well-predicted (season-wide MAD was 8.2%) considering the unusually small size of the run (38), relative to the expected (239). The Upper Columbia PIT-tagged runs-at-large were not, in general as well-predicted as the Snake River Runs. The subyearling run had a season-wide MAD of 12.7%, its large size due almost entirely to a very large last-half MAD of 16.8% (the first-half performance was extremely good with MAD = 1.5%). The Upper Columbia steelhead run had a first-half MAD of 8.0%, and last-half MAD of 3.2%, with the season-wide MAD equal to 4.9%.

Comparison of passage predictions based on similar-flow years rather than all historical years showed that yearling chinook stocks were better-predicted using low-flow years alone. However, steelhead and subyearling chinook passage was predicted more accurately using all historical years.

RealTime predictions of passage and run-timing for the FPC passage-indexed runs-at-large of combined wild and hatchery fish to Rock Island and McNary dams were comparable to last year with some differences in best and worst performers. Coho and subyearling chinook salmon predicted to Rock Island Dam were the best-predicted while this year coho salmon and steelhead were predicted the best. Dramatic changes in RealTime performance, observed for runs such as sockeye salmon (2000 first-half MAD was 19.5% and 2001 first-half MAD was 3.6%) are probably explained by the difference in timing of discharges of large releases of hatchery fish into the river. The runs best-predicted in 2000 to McNary Dam were coho and yearling chinook salmon, and that remained true in 2001, although the extremely good predictions of last year (0.6% and 0.7% season-wide MADs for yearling chinook and coho salmon respectively) were not seen this year (MADs were 5.7% and 2.6%, respectively). The subyearling chinook salmon runs to both dams were not as well-predicted this year as they were in 2000. The season-wide MAD for the run to Rock Island Dam was 9.1%, compared to 2.9% last year. The season-wide MAD to McNary was up from 1.6% in 2000 to 6.3% in 2001. The new run to John Day Dam of subyearling chinook salmon had a first-half MAD of 16.0%, and a season-wide MAD of 10.0%.

5.0 Recommendations

It is recommended that the new stocks added to the 2001 RealTime project remain in the project for 2002. The 2001 RealTime project supplied accurate and critical information about passage and run-timing for the PIT-tagged runs-at-large of wild ESUs to McNary Dam. It is further recommended that wild PIT-tagged runs-at-large of all salmonid species be tracked and forecasted to Lower Granite and McNary dams, and furthermore, that an all-species run of wild PIT-tagged fish be added to the project in 2002.

Refinements to the RealTime project to increase accuracy of run-timing and passage predictions should be evaluated annually for effectiveness, including 1) formulas to upwardly adjust raw PIT-detections for spill and other undetected routes of passage through hydroelectric projects, 2) calibration procedures to optimize RealTime performance, and 3) utilization of similar-flow-year predictions.

6.0 Conclusions and Summary

The results of evaluating Program RealTime for accuracy in predicting passage percentages and run-timing characteristics of Snake and Upper Columbia River salmon and steelhead runs in 2001 were mixed. Some stocks new to the RealTime project this year were predicted with very good accuracy, and some that have a long history in the project were predicted with much better-than-average accuracy. On the other hand, the RealTime Select Composite, a measure of overall performance for predictions of wild release-recapture spring/summer yearling chinook salmon stocks tracked to Lower Granite Dam, stocks tracked since the inception of the project, recorded the largest MADs of any year. First-half performance for these ten stocks of long standing was somewhat reminiscent of 1998 dynamics, which, like 2001, recorded unusually high recovery percentages. Unlike 1998 which recorded better-than-average last-half performance, 2001 last-half performance was worse (Appendix D). The average of the ten season-wide MADs was 7.0% in 2001 compared to the overall average of 3.8% in 2000.

Performance in predicting passage percentiles of the PIT-tagged runs-at-large of wild Snake River subyearling and yearling chinook salmon and steelhead to Lower Granite and McNary dams was very good, with season-wide MADs for these three runs to Lower Granite Dam equal to

4.8%, 3.6% and 1.8%, respectively. The season-wide MADs for these runs to McNary Dam were 4.7%, 3.3% and 1.4% respectively. The PIT-tagged runs-at-large of wild Upper Columbia River subyearling chinook salmon and steelhead tracked to McNary Dam were also predicted well, though not as well as the Snake River runs, with season-wide MADs of 7.9% and 4.9%, respectively.

PIT-tagged hatchery sockeye salmon from the Redfish Lake area to Lower Granite Dam were forecasted with accuracy comparable to that for other stocks tracked by Program RealTime in previous years from that area (i.e., Redfish Lake and Alturas Lake), with season-wide MAD equal to 6.4%. The new run of PIT-tagged wild Snake River sockeye salmon tracked to McNary had a season-wide MAD of 6.0%.

The runs-at-large of combined hatchery and wild passage-indexed subyearling and yearling chinook salmon, coho and sockeye salmon and steelhead to Rock Island and McNary dams were predicted moderately well, with 3 out of eleven predicted to within 5.0% of the true season-wide distribution on average, and all but one predicted to within 10%. In general the worst predictions in 2001 were better than the worst of 2000, but the best predictions in 2001 were not as good as the best predictions last year. Like last year, there was considerable range in performance, with very good performance evidenced for some stocks (coho salmon to both dams) and poorer performance for others (sockeye salmon to Rock Island Dam). Poor performances for these stocks were probably due, like last year, to large releases of hatchery fish swamping the normal pattern of fish passage. In general the subyearling chinook salmon runs to all dams, including to John Day Dam (a new run) were not predicted as well as the other species of fish, or as well as last year.

Run-timing characteristics were unusual in 2001 insofar as many stocks (17 out of 21 PIT-tagged stocks) had a shorter-than-average middle 80% passage period, with over a third of these stocks recording the shortest middle 80% period of any year. The concurrent observations of higher-than-average detection rates for yearling chinook salmon stocks, along with the fact of no spill at Lower Granite Dam warrants further study to determine whether low-flow years can be better predicted. Comparisons of passage predictions based on all historical years versus low-flow years (1992, 1994) revealed that yearling chinook salmon stocks were better predicted using low-flow years while subyearling chinook salmon and steelhead were better predicted using all years of available data.

7.0 Literature Cited

Achord, S., M.B. Eppard, E.E. Hockersmith, B.P. Sandford, G.A. Axel, G.M. Matthews. 2000. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1998. National Marine Fisheries Service, Seattle, Washington. Annual Report 1998 (DOE/BP-18800-7) to Bonneville Power Administration, Project 9102800, Contract DE-A179-91BP18800. 89p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Achord, S., M.B. Eppard, E.E. Hockersmith, B.P. Sandford, G.M. Matthews. 1998. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1997. National Marine Fisheries Service, Seattle, Washington. Annual Report 1997 (DOE/BP-18800-6) to Bonneville Power Administration, Project 9102800, Contract DE-A179-91BP18800. 86p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Achord, S., M.B. Eppard, E.E. Hockersmith, B.P. Sandford, G.M. Matthews. 1997. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, annual report 1996. National Marine Fisheries Service, Seattle, Washington. Annual Report 1996 (DOE/BP-18800-5) to Bonneville Power Administration, Project 9102800, Contract DE-A179-91BP18800. 86p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Achord, S., M.B. Eppard, B.P. Sandford, G.M. Matthews. 1996. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1995. National Marine Fisheries Service, Seattle, Washington. Annual Report 1995 (DOE/BP-18800-4) to Bonneville Power Administration, Project 9102800, Contract DE-A179-91BP18800. 194p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Achord, S., D.J. Kamikawa, B.P. Sandford, G.M. Matthews. 1995. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1993. National Marine Fisheries Service, Seattle, Washington. Annual Report 1993 (DOE/BP-18800-2) to Bonneville Power Administration, Project 9102800, Contract DE-A179-91BP18800. 100p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Achord, S., G.M. Matthews, D.M. Marsh, B.P. Sandford, D.J. Kamikawa. 1994. Monitoring the migrations of wild Snake River spring/summer chinook salmon smolts, 1992. National Marine Fisheries Service, Seattle, Washington. Annual Report 1992 (DOE/BP-18800-1) to Bonneville Power Administration, Project 9102800, Contract DE-A179-91BP18800. 88p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Ashe, B. L., A. C. Miller, P. A. Kucera and M. L. Blenden. 1995. Spring Outmigration of Wild and Hatchery Chinook Salmon and Steelhead Trout Smolts from Imnaha River, March 1 - June 15, 1994. Nez Perce Tribe, Department of Fisheries Resources Management, Lapwai, Idaho.

Technical Report (DOE/BP-38906-4) to Bonneville Power Administration, Project 87-127, Contract DE-FC79-88BP38906. 76 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Beer, N., J.A. Hayes, R. Zabel, P. Shaw, J.J. Anderson. 1999. Evaluation of the 1998 Predictions of the Run-Timing of Wild Migrant Yearling Chinook in the Snake River Basin using CRiSP/RT. Report to Bonneville Power Administration, Project 89-108, Contract DE-B179-89BP02347.

Blenden, M. L., R. S. Osborne and P. A. Kucera. 1996. Spring outmigration of wild hatchery chinook salmon and steelhead trout smolts from the Imnaha River, Oregon, February 6-June 20, 1995. Nez Perce Tribe, Department of Fisheries Resources Management, Lapwai, Idaho. Annual Report 1995 (DOE/BP-38906-5a) to Bonneville Power Administration, Project 87-127, Contract DE-FC79-88BP38906. 74 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Burgess, C., J. R. Skalski, and D. Yasuda. 1999. Evaluation of the 1998 Predictions of the Run-Timing of Wild Migrant Yearling and Subyearling Chinook and Steelhead, and hatchery Sockeye in the Snake River Basin Using Program RealTime. School of Fisheries, University of Washington, Seattle, Washington. Technical Report to Bonneville Power Administration, Portland, Oregon, Project 91-051-00, Contract 96BI-91572. 43 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Burgess, C. and J. R. Skalski. 2000a. Evaluation of the 1999 Predictions of the Run-Timing of Wild Migrant Yearling and Subyearling Chinook Salmon and Steelhead Trout, and hatchery Sockeye Salmon in the Snake River Basin Using Program RealTime. School of Fisheries, University of Washington, Seattle, Washington. Technical Report submitted to Bonneville Power Administration, Portland, Oregon, Project 91-051-00, Contract 96BI-91572. 30 p.

Burgess, C. and J. R. Skalski. 2000b. Evaluation of the 2000 Predictions of the Run-Timing of Wild Migrant Chinook Salmon and Steelhead Trout, and Hatchery Sockeye Salmon in the Snake River Basin, and Combined Wild and Hatchery Salmonids migrating to Rock Island and McNary Dams using Program RealTime. School of Fisheries, University of Washington, Seattle, Washington. Technical Report submitted to Bonneville Power Administration, Portland, Oregon, Project 91-051-00, Contract 96BI-91572. 37 p.

Burgess, C. and J.R. Skalski. 2000c. Effectiveness of a New Calibration Procedure for Improving the Accuracy of Program RealTime Run-Time Predictions for Snake and Columbia River Salmonids. School of Fisheries, University of Washington, Seattle, Washington. Letter Report submitted to Bonneville Power Administration, Portland, Oregon, Project 91-051-00, Contract 96BI-91572. 37 p.

Connor, W.P., H. Burge and R. Bugert. 1992. Migration timing of natural and hatchery fall chinook in the Salmon River Basin. Pages 46-56 in Passage and survival of juvenile chinook salmon migrating from the Snake River Basin. Proceedings of a technical workshop. Prepared by the Idaho Chapter of the American Fisheries Society, Idaho Water Resources Institute, University of Idaho Cooperative Fish and Wildlife Research Unit and the Western Division of the American Fisheries Society.

Connor, W.P., H.L. Burge and W.H. Miller. 1993. Rearing and emigration of naturally produced Snake River fall chinook salmon juveniles. Pages 81-116 *In* D.W. Rondorf and W.H. Miller, editors. Identification of the spawning, rearing and migratory requirements of fall chinook in the Columbia River Basin. 1991 Annual Report to Bonneville Power Administration (DOE/BP-21708-1), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Connor, W.P., H.L. Burge and W.H. Miller. 1994a. Rearing and emigration of naturally produced Snake River fall chinook salmon juveniles. Pages 92-119 *In* D.W. Rondorf and W.H. Miller, editors. Identification of the spawning, rearing and migratory requirements of fall chinook in the Columbia River Basin. 1992 Annual Report to Bonneville Power Administration (DOE/BP-21708-2), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Connor, W.P., H.L. Burge, D. Steele, C. Eaton and R. Bowen. 1994b. Rearing and emigration of naturally produced Snake River fall chinook salmon juveniles. Pages 41-73 *In* D.W. Rondorf and K.F. Tiffan, editors. Identification of the spawning, rearing and migratory requirements of fall chinook in the Columbia River Basin. 1993 Annual Report to Bonneville Power Administration (DOE/BP-21708-3), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Connor, W.P., H.L. Burge, R.D. Nelle, C. Eaton and R. Waitt. 1996. Rearing and emigration of naturally produced Snake River fall chinook salmon juveniles. Pages 44-63 *In* D.W. Rondorf and K.F.Tiffan, editors. Identification of the spawning, rearing and migratory requirements of fall chinook in the Columbia River Basin. 1994 Annual Report to Bonneville Power Administration (DOE/BP-21708-4), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Connor, W.P., T.C. Bjornn, H.L. Burge, A. Garcia, and D.W. Rondorf. 1997. Early life history and survival of natural subyearling fall chinook salmon in the Snake and Clearwater rivers in 1995. *In* D. Rondorf and K. Tiffan (editors), Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin, p. 18-47. Annual Report to Bonneville Power Administration, Contract DE-AI79-91BP21708, 112 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Connor, W.P., H.L. Burge, D.H. Bennett. 1998. Detection of PIT-tagged Subyearling Chinook Salmon at a Snake River Dam: Implications for Summer Flow Augmentation. North American Journal of Fisheries Management:530-36.

Connor, W.P., and several co-authors. In preparation-b. Fall chinook salmon spawning habitat availability in the Snake River. A manuscript to be submitted to the North American Journal of Fisheries Management in 1999.

Fish Passage Center of the Columbia Basin Fish and Wildlife Authority. 1999. Fish Passage Center Weekly Report #99-23 (Available from Fish Passage Center of the Columbia Basin Fish and Wildlife Authority, 2501 SW First Avenue, Suite 230, Portland, OR 97201-4752.)

Giorgi, A. E., and J. W. Schlechte. 1997. An evaluation of the effectiveness of flow augmentation in the Snake River, 1991-1995. Phase I Final Report (DOE/BP-24576-1) to Bonneville Power Administration 95-070-00, Contract DE-AC79-92BP24576. 47p. plus appendices. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Hayes, J. A., R. Zabel, P. Shaw, J. J. Anderson. 1996. Evaluation of the 1996 predictions of the run-timing of wild migrant yearling chinook at multiple locations in the Snake and Columbia River Basins using CRiSP/RealTime. Center for Quantitative Science, School of Fisheries, University of Washington, Seattle, Washington. Technical Report to Bonneville Power Administration Project 89-108, Contract DE-BI79-89BP02347. 74 p.

Healey, M.C. 1991. Life History of Chinook Salmon (Oncorhynchus tshawytscha). In Pacific Salmon Life Histories, Groot, C. and L. Margolis, editors. 1991. UBC Press, Vancouver, Canada. 564 p.

Keefe, M. L., D. J. Anderson, R. W. Carmichael and B. C. Jonasson. 1996. Early life history study of Grande Ronde River Basin chinook salmon. Oregon Department of Fish and Wildlife, Fish Research Project. 1995 Annual Report (D147 DOE/BP-33299-1B) to the Bonneville Power Administration, Portland, Oregon, Project 92-026-04, Contract 94BI33299. 39p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Marshall, A., W.P. Connor, and several co-authors. Stock and race identification of subyearling chinook salmon in the Snake River. Submitted to Transactions of the American Fisheries Society in 1998.

Nelson, W.R., L.K. Freidenburg and D.W. Rondorf. Accepted. Swimming behavior and performance of emigrating subyearling chinook salmon. Transactions of the American Fisheries Society.

NMFS. 2000. White Paper. Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams, April 2000. Available at www.nwfsc.noaa.gov/pubs/nwfscpubs.html.

OWICU. 1996. Memorandum dated June 3, 1996, prepared by technical staffs of the Columbia River salmon management agencies to Implementation Team: Review of Fall Chinook Juvenile Migration Data. 19 p.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1990a. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. Am. Fish. Soc. Symp. 7:317-322.

Prentice, E.F., T.A. Flagg, C.S. McCutcheon, and D.F. Brastow. 1990b. PIT-tag monitoring systems for hydroelectric dams and fish hatcheries. Am. Fish. Soc. Symp. 7:323-334.

Prentice, E.F., T.A. Flagg, C.S. McCutcheon, D.F. Brastow, and D.C. Cross. 1990c. Equipment, methods, and an automated data-entry station for PIT tagging. Am. Fish. Soc. Symp. 7:335-340.

Rondorf, D.W., and W.H. Miller, editors. 1993. Identification of the spawning, rearing and migratory requirements of fall chinook salmon in the Columbia River basin. 1991 Annual Report to Bonneville Power Administration (DOE/BP-21708-1), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Rondorf, D.W., and W.H. Miller, editors. 1994a. Identification of the spawning, rearing and migratory requirements of fall chinook salmon in the Columbia River basin. 1992 Annual Report to Bonneville Power Administration (DOE/BP-21708-2), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Rondorf, D.W., and K.F. Tiffan, editors. 1994b. Identification of the spawning, rearing and migratory requirements of fall chinook salmon in the Columbia River basin. 1993 Annual Report to Bonneville Power Administration (DOE/BP-21708-3), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Rondorf, D.W., and K.F. Tiffan, editors. 1996. Identification of the spawning, rearing and migratory requirements of fall chinook salmon in the Columbia River basin. 1994 Annual Report to Bonneville Power Administration (DOE/BP-21708-4), Contract DEAI79-91BP21708, Portland, Oregon. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Smith, S.G., J.R. Skalski, A. Giorgi. 1993 Statistical Evaluation of Travel Time Estimation Based on Data From Freeze-Branded Chinook Salmon on the Snake River, 1982-1990. Technical Report (DOE/BP-35885-4) to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract DE-B179-91BP35885. 113 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Smith, S. G., W. D. Muir, E. E. Hokersmith, M. B. Eppard, and W. P. Connor. 1997. Passage survival of natural and hatchery subyearling fall chinook salmon to Lower Granite, Little Goose, and Lower Monumental Dams. Pages 1-65 *In* J. G. Williams and T. C. Bjornn, editors. Fall chinook salmon survival and supplementation studies in the Snake and Lower Columbia River Reservoirs, 1995. Annual Report (DOE-BP-10891-4) to Bonneville Power Administration, Portland, Oregon, Project 93-029, Contract 93AI10891 and the U.S. Army Corps of Engineers, Contract E86950141. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Skalski, J. R., G. Tartakovsky, S. G. Smith and P. Westhagen. 1994. Pre-1994 Season Projection of Run-Timing Capabilities Using PIT-tag Databases. Center for Quantitative Science, School of Fisheries, University of Washington, Seattle, Washington. Technical Report (DOE/BP-35885-7) to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract DE-BI79-87BP35885. 67 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Tiffan, K.F., and several co-authors. In preparation-a. Morphological differences between emigrating juvenile spring and fall chinook salmon in the Snake River. A manuscript to be submitted to the Transactions of the American Fisheries Society in 1999.

Tiffan, K.F., and several co-authors. In review-b. Marking subyearling chinook salmon to estimate adult contribution in the Columbia River. A manuscript submitted to the North American Journal of Fisheries Management.

Townsend, R. L., P. Westhagen, D. Yasuda and J. R. Skalski. 1995. Evaluation of the 1994 Predictions of the Run-Timing of Wild Migrant Yearling Chinook in the Snake River Basin. Center for Quantitative Science, School of Fisheries, University of Washington, Seattle, Washington. Technical Report (DOE/BP-35885-8) to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract DE-BI79-87BP35885. 93 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Townsend, R. L., P. Westhagen, D. Yasuda, J. R. Skalski, and K. Ryding. 1996. Evaluation of the 1995 Predictions of the Run-Timing of Wild Migrant Yearling Chinook in the Snake River Basin using Program RealTime. Center for Quantitative Science, School of Fisheries, University of Washington, Seattle, Washington. Technical Report (DOE/BP-35885-9) to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract DE-BI79-87BP35885. 64 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Townsend, R. L.,D. Yasuda, and J. R. Skalski. 1997. Evaluation of the 1996 Predictions of the Run-Timing of Wild Migrant Spring/Summer Yearling Chinook in the Snake River Basin Using Program RealTime. School of Fisheries, University of Washington, Seattle, Washington. Technical Report (DOE/BP-91572-1) to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract 96BI91572. 30 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Townsend, R. L., J. R. Skalski, and D. Yasuda. 1998a. Evaluation of the 1996 Predictions of the Run-Timing of Wild Migrant Subyearling Chinook in the Snake River Basin Using Program RealTime. School of Fisheries, University of Washington, Seattle, Washington. Technical Report (accepted) to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract DE-BI79-87BP35885. 31 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

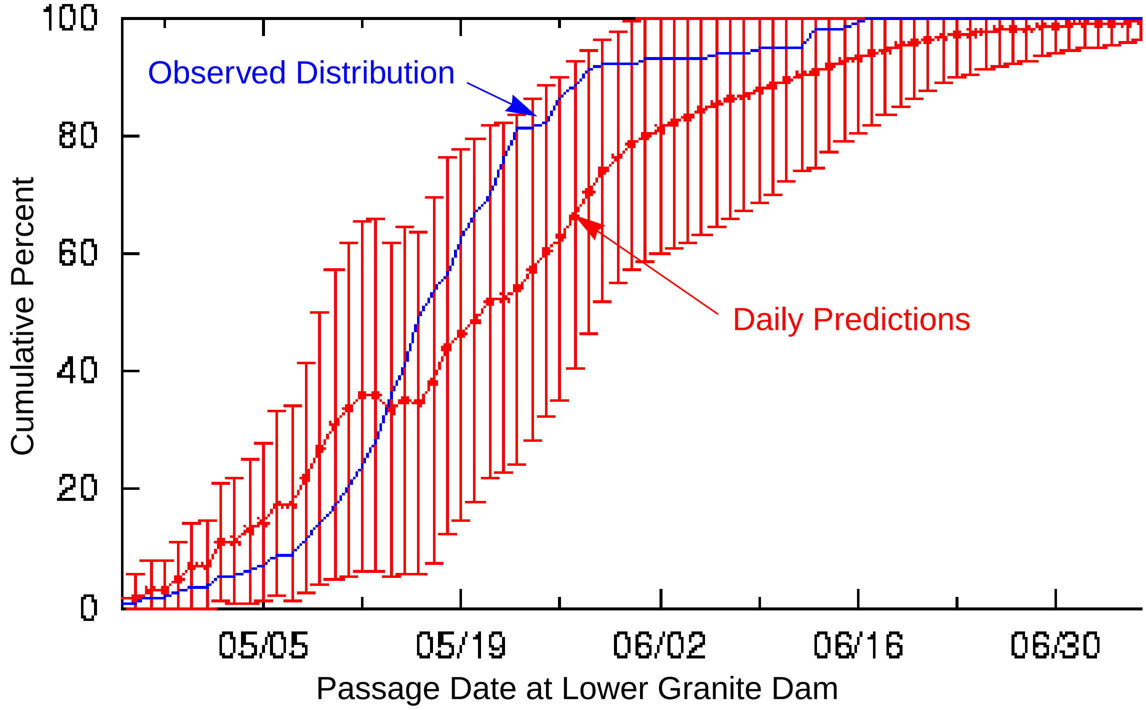
Townsend, R. L., J. R. Skalski, and D. Yasuda. 2000. Evaluation of the 1997 Predictions of the Run-Timing of Wild Migrant Yearling and Subyearling Chinook and Sockeye in the Snake River Basin Using Program RealTime. School of Fisheries, University of Washington, Seattle, Washington. Technical Report to Bonneville Power Administration, Portland, Oregon, Project 91-051, Contract DE-BI79-87BP35885. 30 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, P.O. Box 3621, Portland, OR. 97283-3621.)

Appendix A

<u>Performance Plots for the 2001 Out-migration Season</u>

Figure A1: Bear Valley Creek and Catherine Creek Daily Predictions

Bear Valley Creek



Catherine Creek

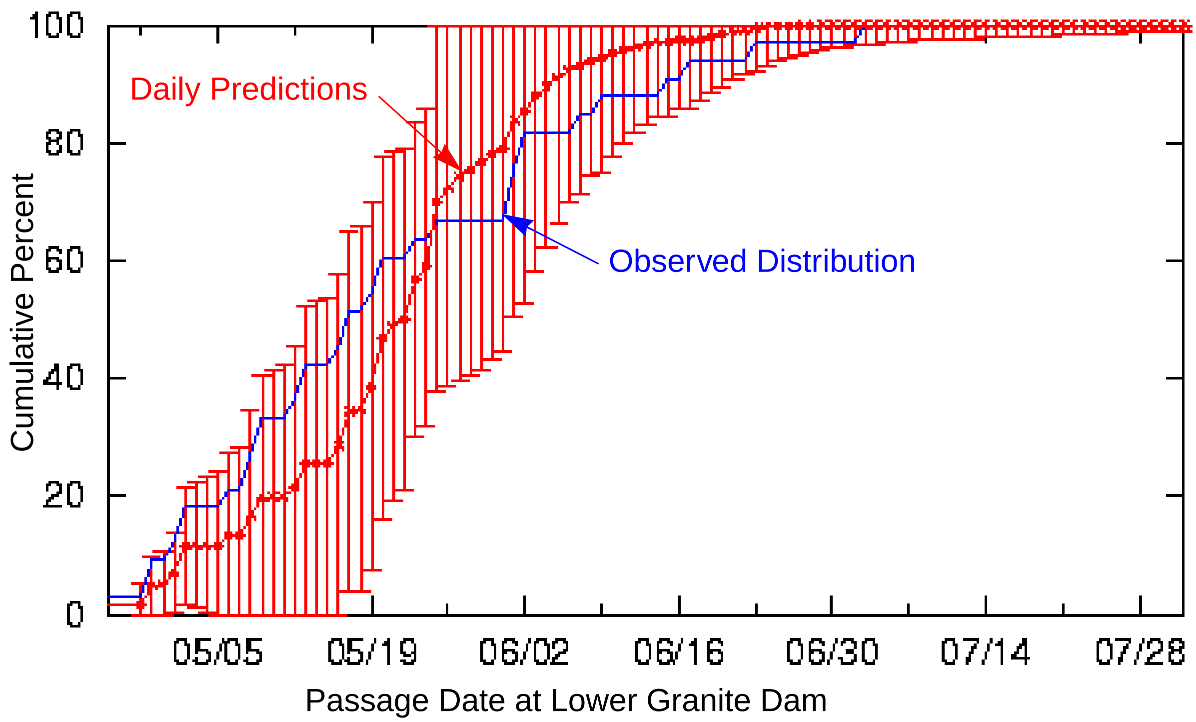
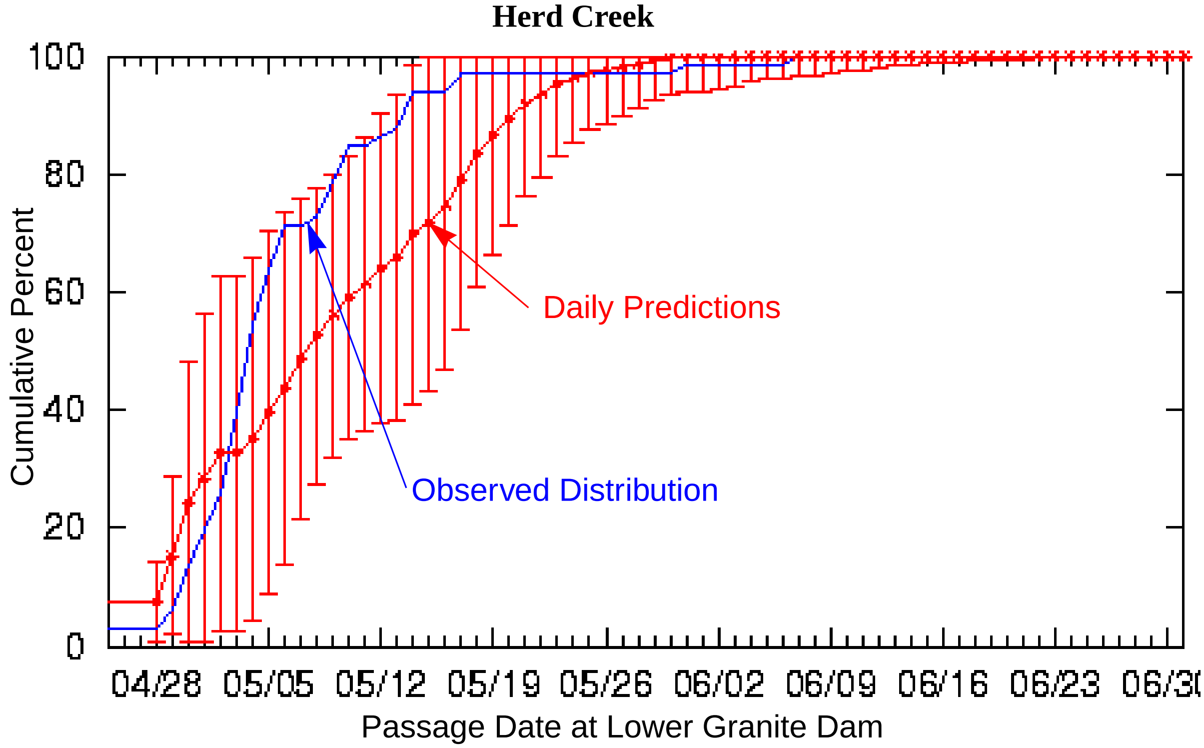


Figure A2: Herd Creek and Imnaha River Daily Predictions



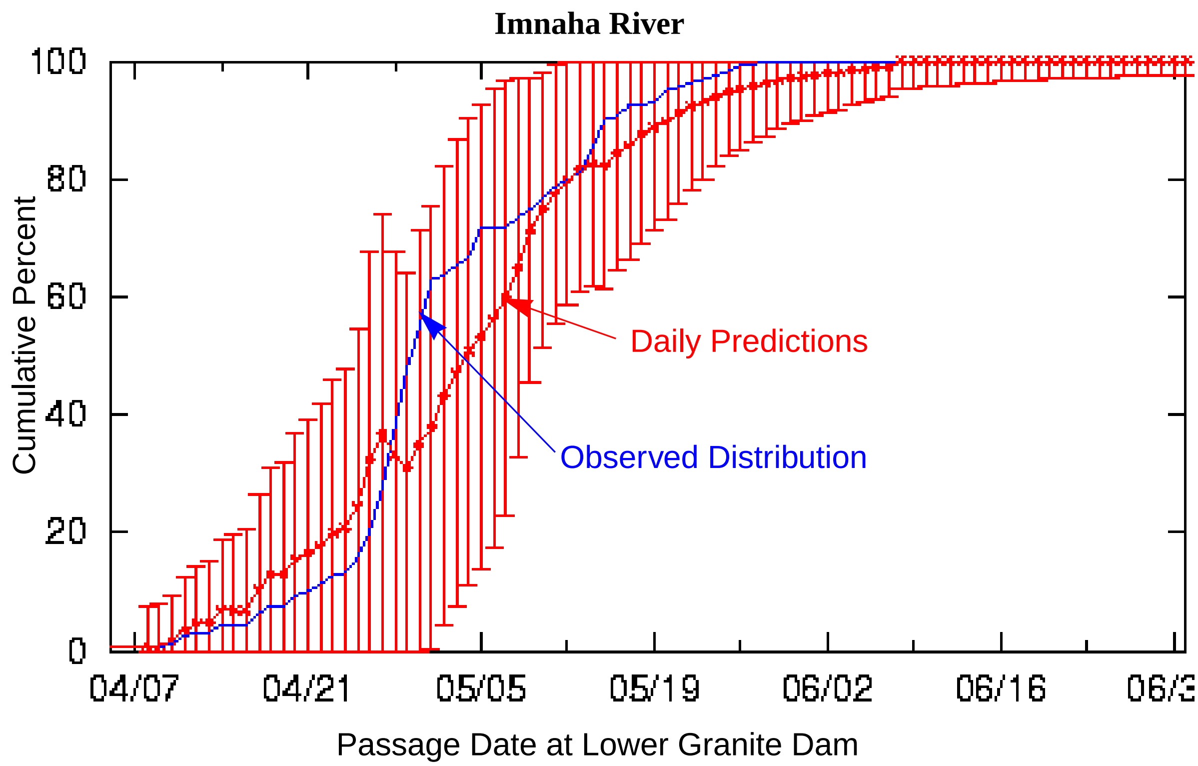
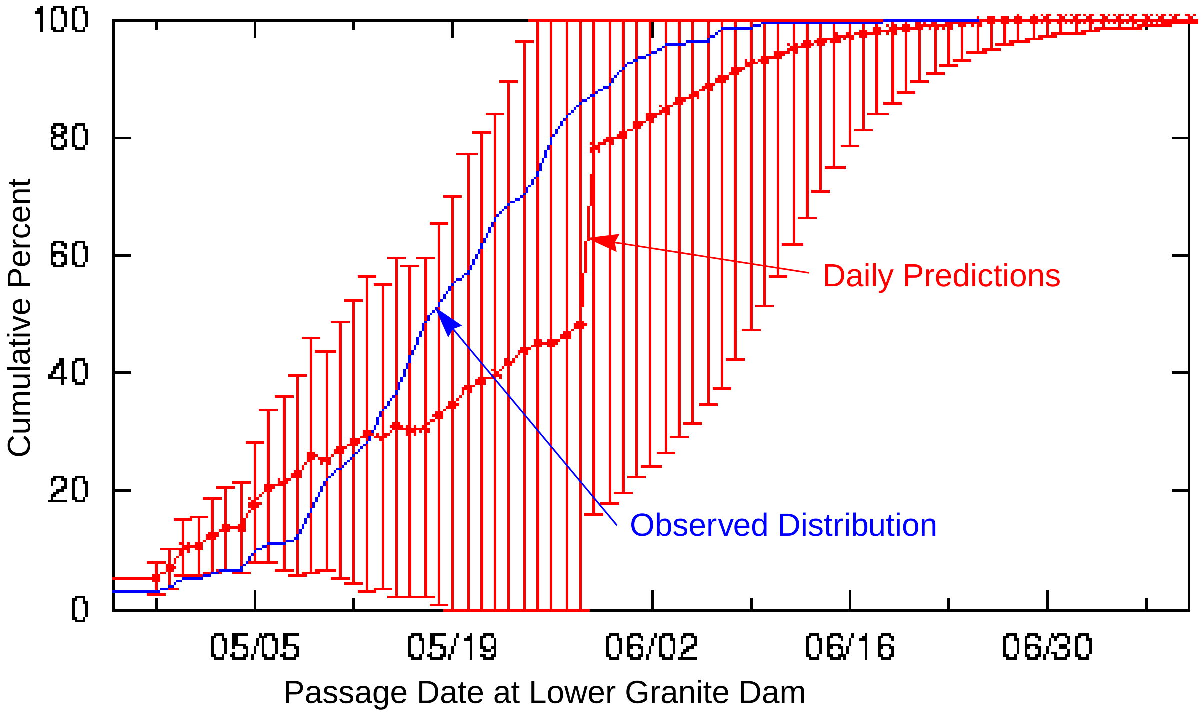


Figure A3: Johnson Creek and Lostine River Daily Predictions.

Johnson Creek



Lostine River

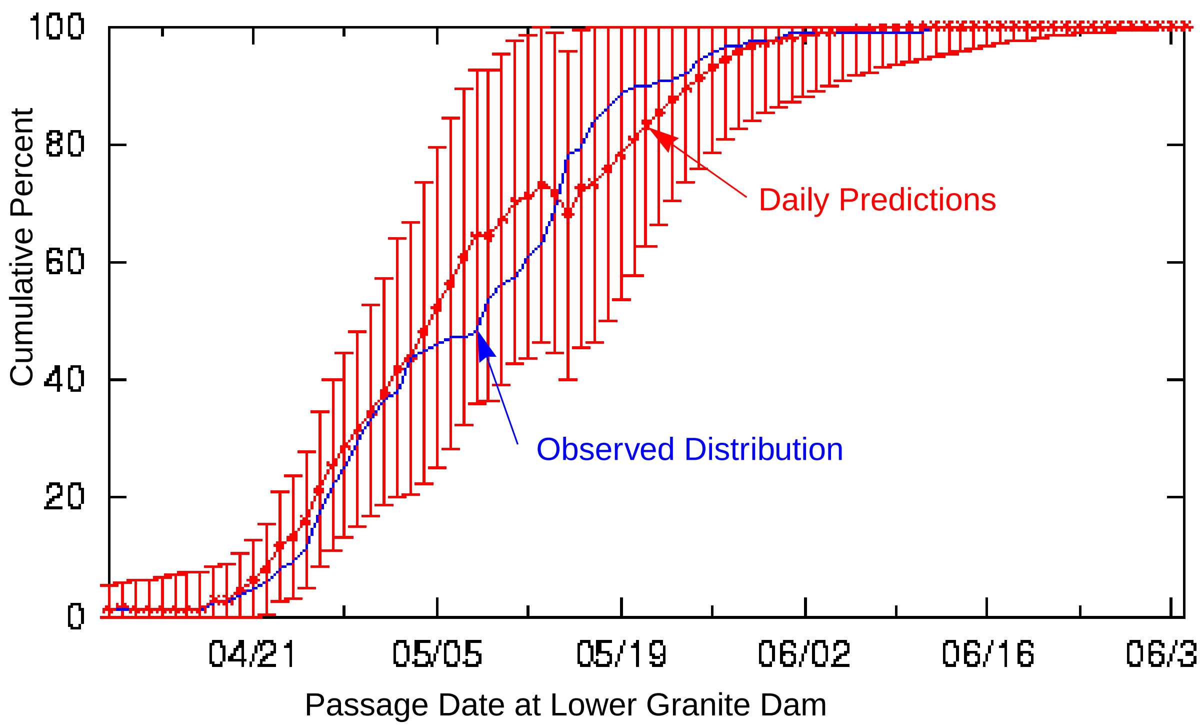
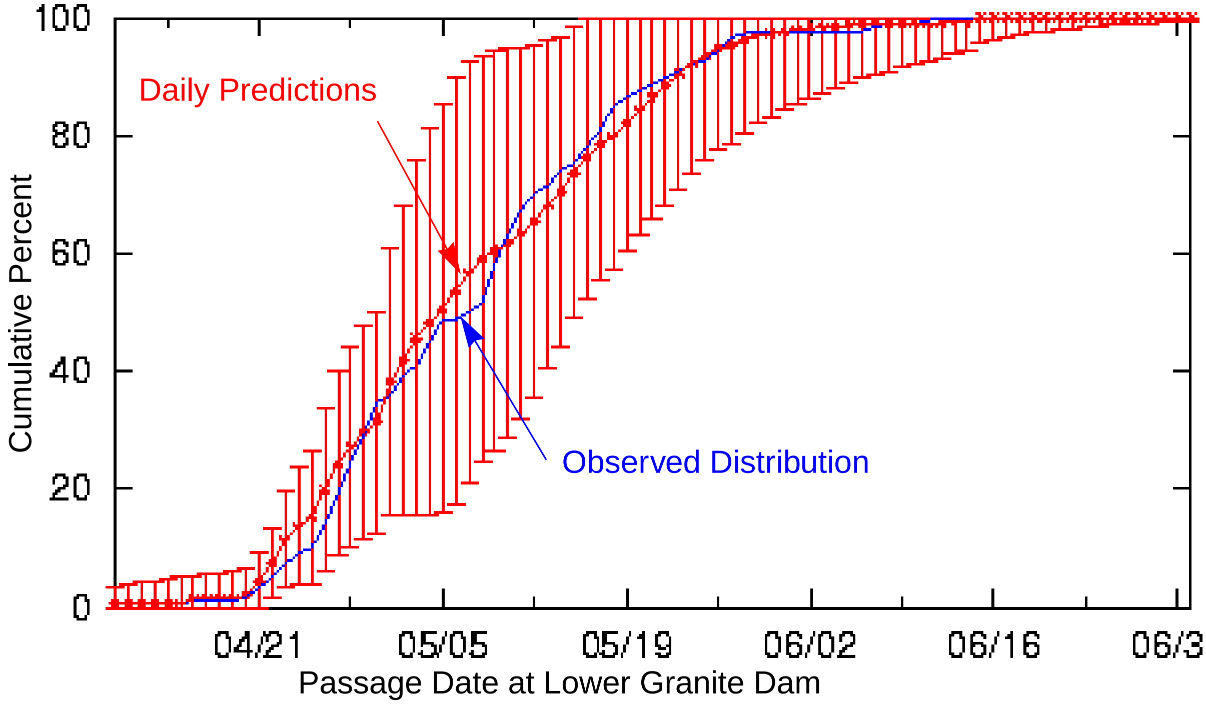


Figure A4: Minam River and Salmon River South Fork Daily Predictions

Minam River



South Fork Salmon River

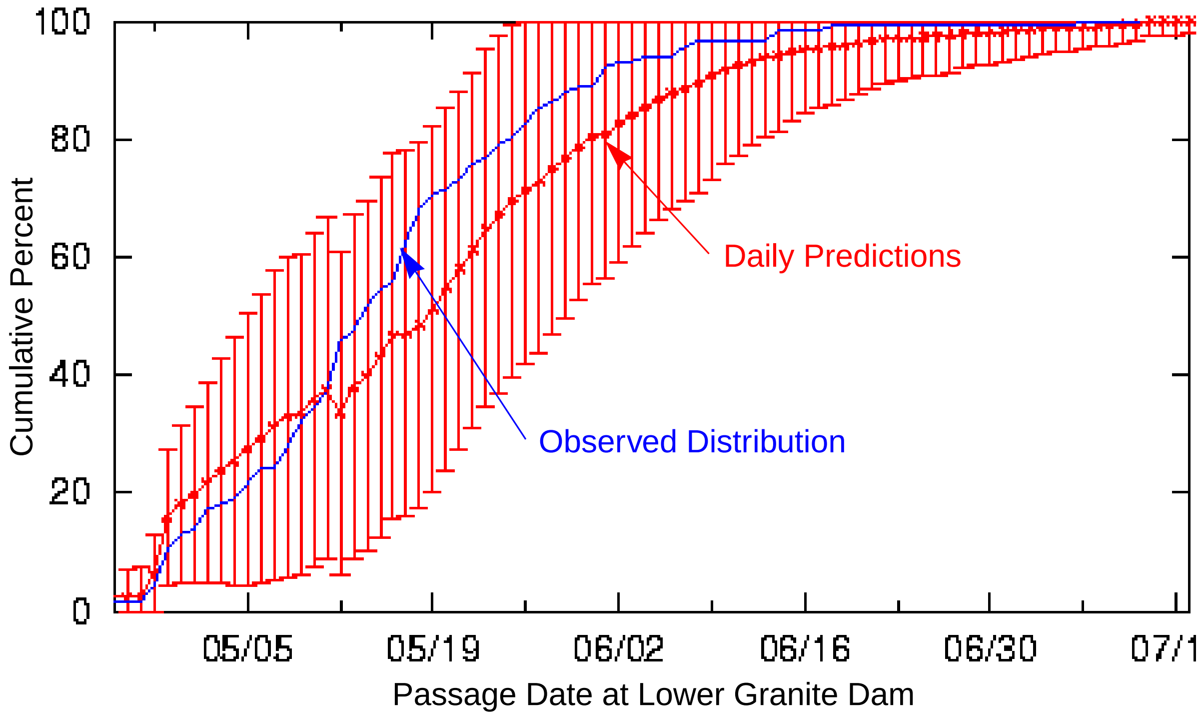
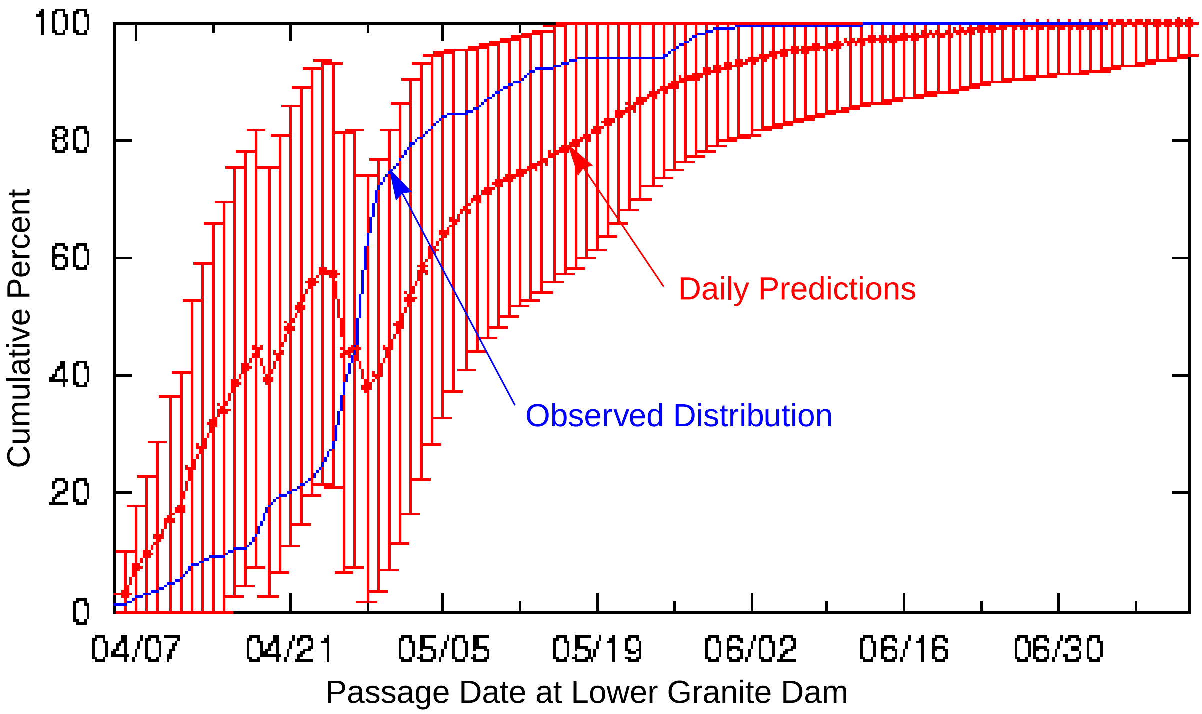


Figure A5. Secesh River and Valley Creek Daily Predictions

Secesh River



Valley Creek

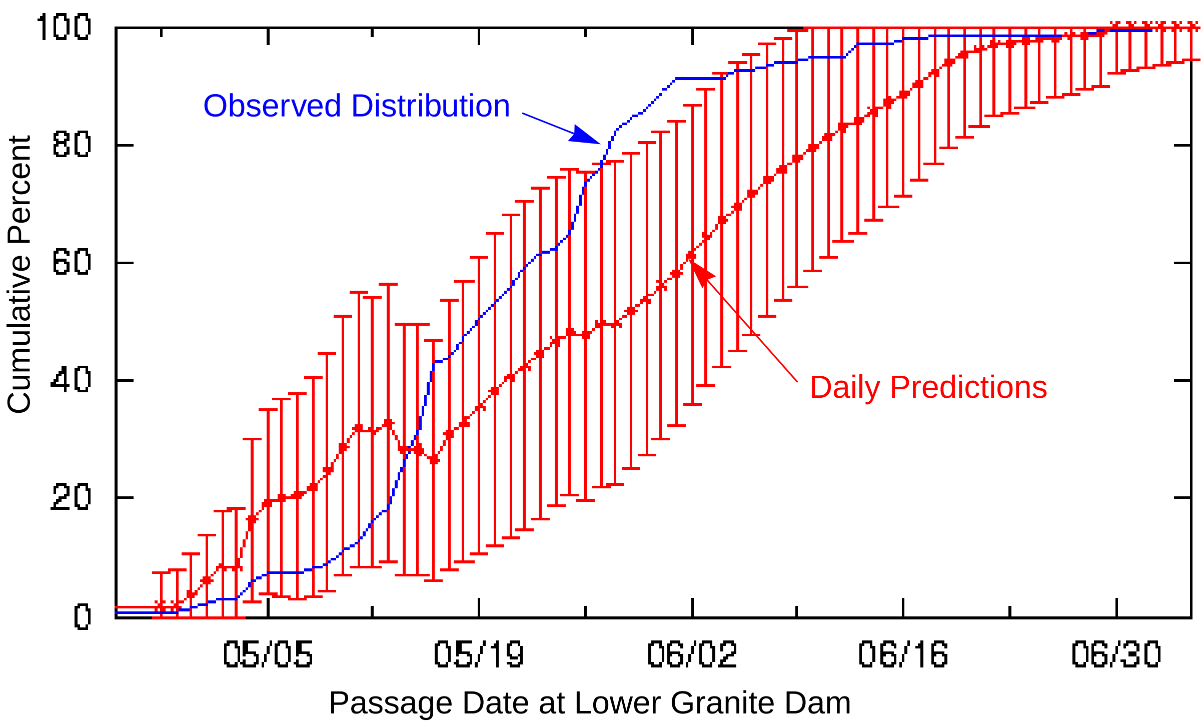
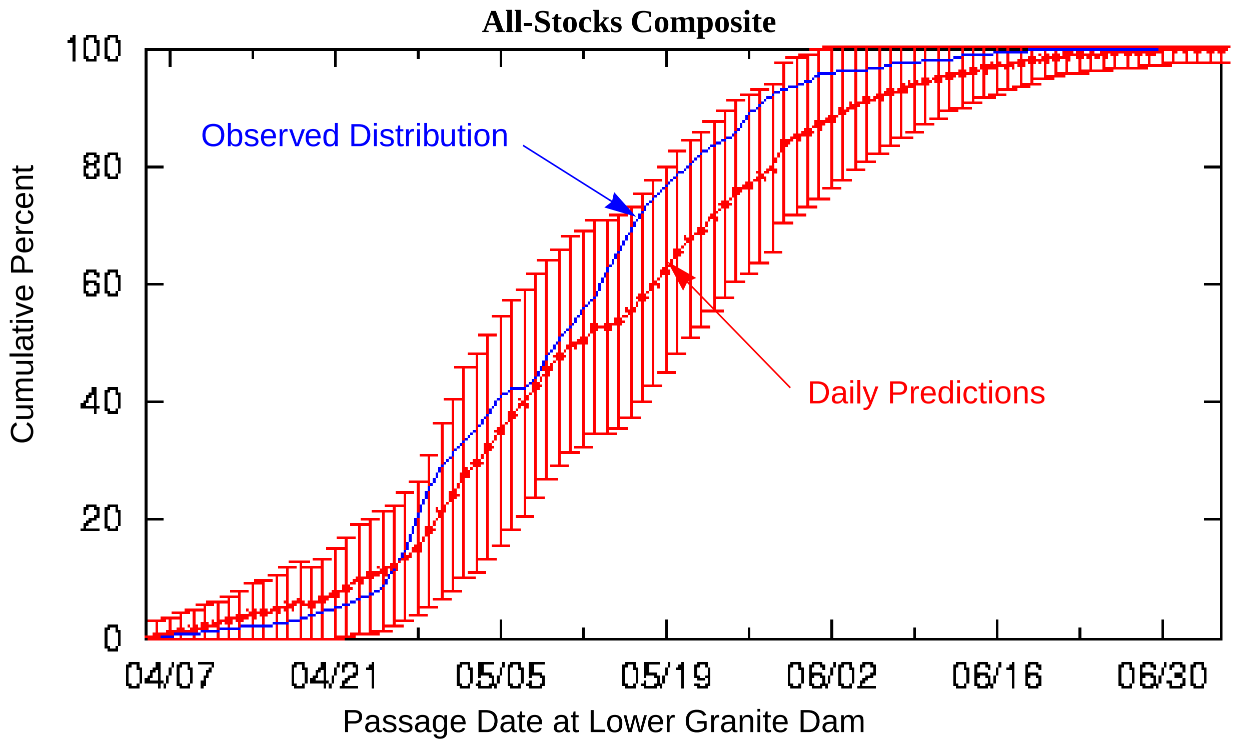


Figure A6. All-Stocks Composite and CRiSP/RealTime Composite Daily Predictions



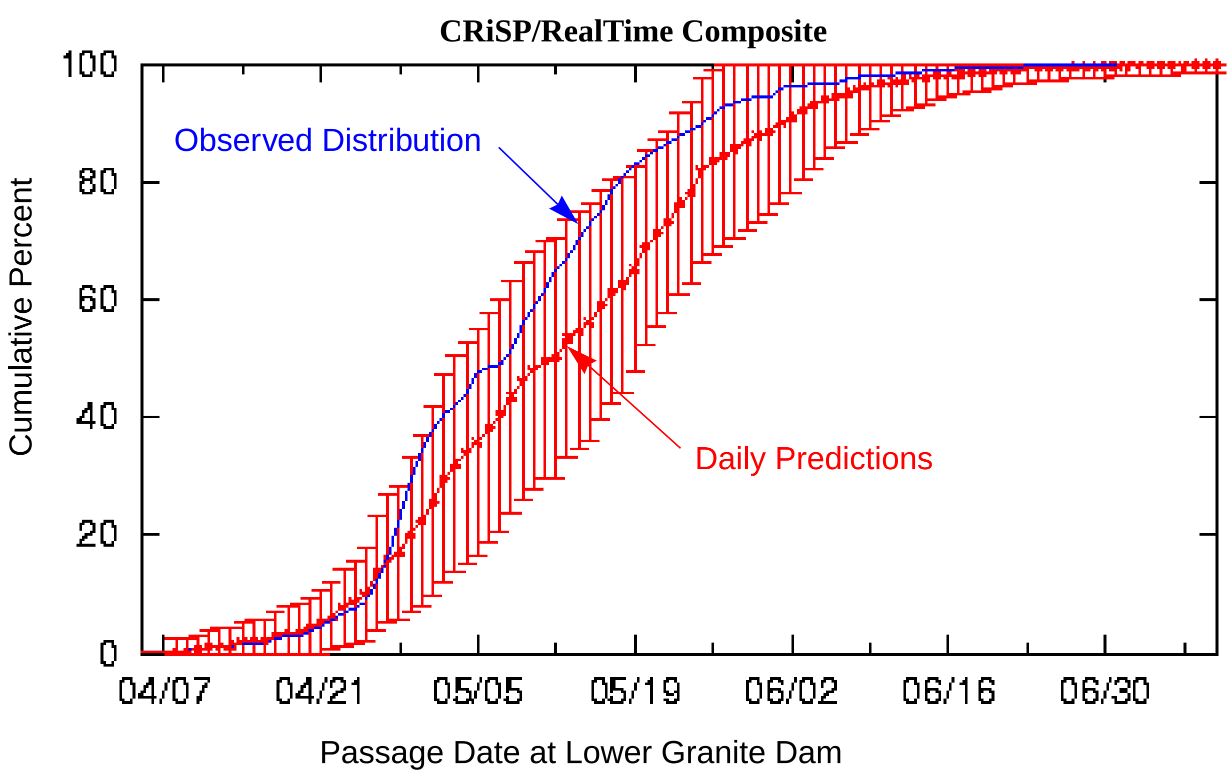
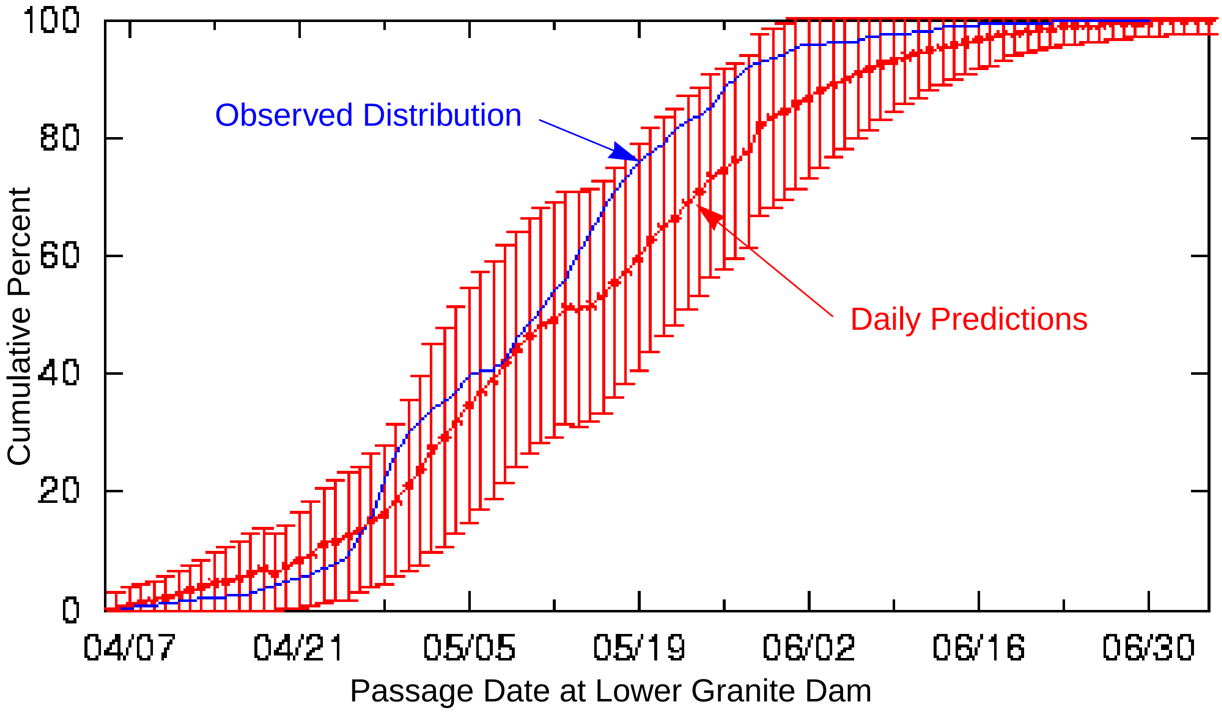


Figure A7. Select Composite and Composite of Hatchery PIT-tagged Sockeye Salmon (from Alturas Lake Creek, Redfish Lake Creek Trap, and Sawtooth Trap) Daily Predictions

CRiSP/RealTime Composite



Composite of Hatchery Sockeye Salmon (ALTULC, RLCTRP, SAWTRP)

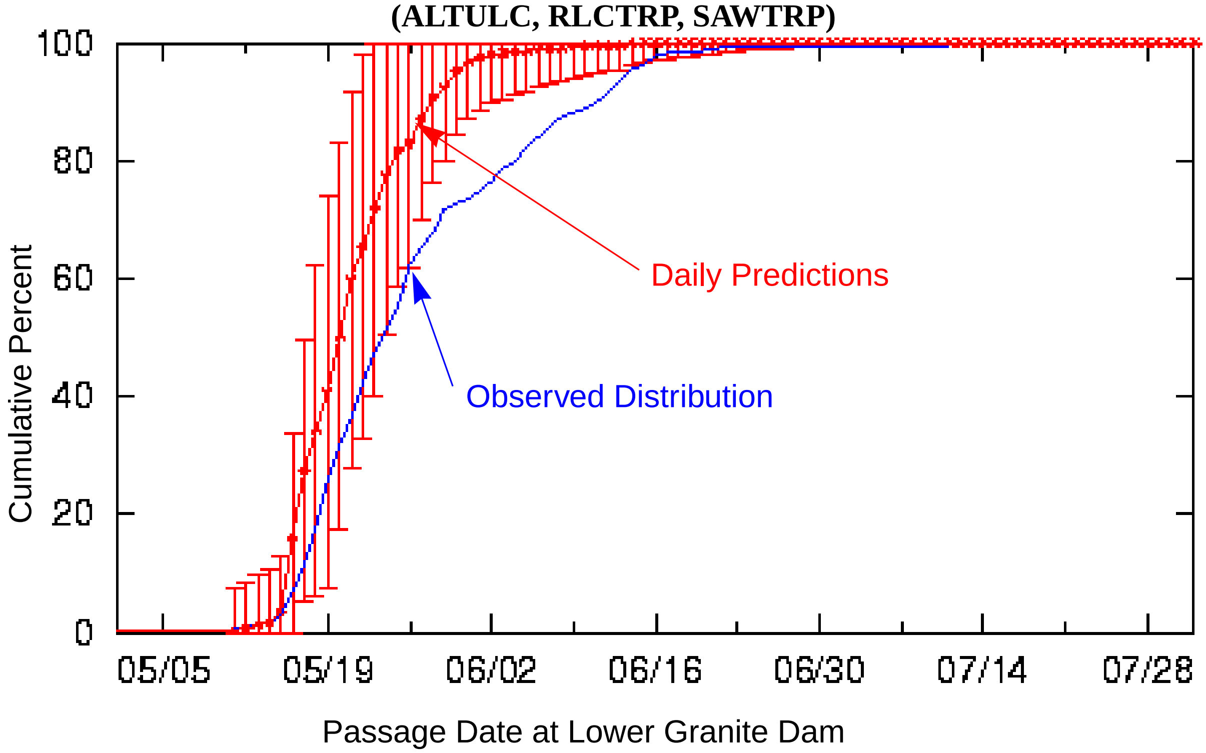
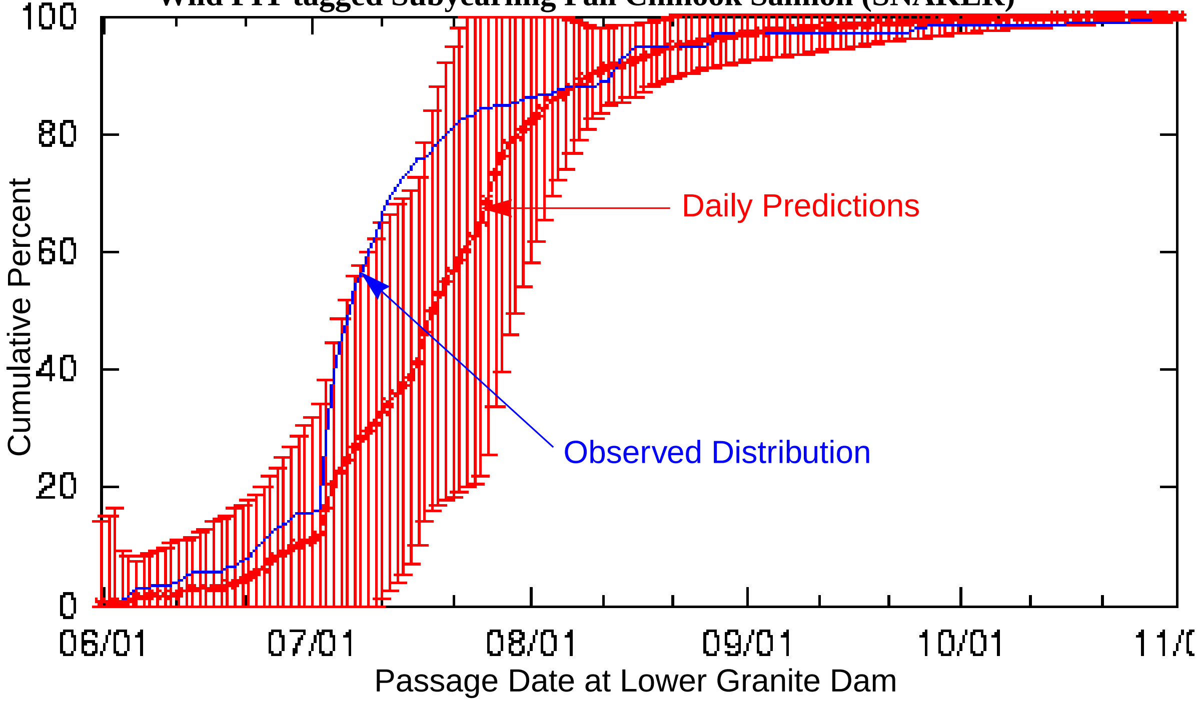


Figure A8: Daily Predictions of wild PIT-tagged Snake River subyearling fall chinook salmon (SNAKER) and of the wild PIT-tagged run-at-large of yearling chinook salmon at Lower Granite Dam.

Wild PIT-tagged Subyearling Fall Chinook Salmon (SNAKER)



Wild PIT-tagged Yearling Chinook Salmon Run-At-Large

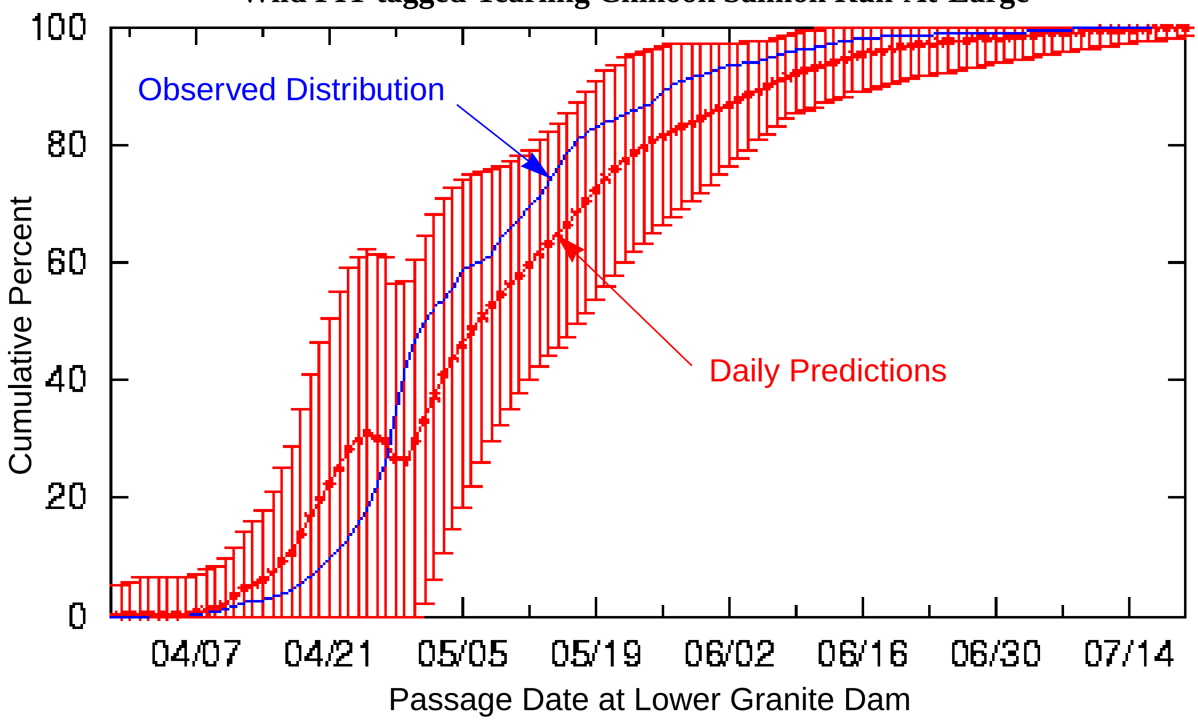
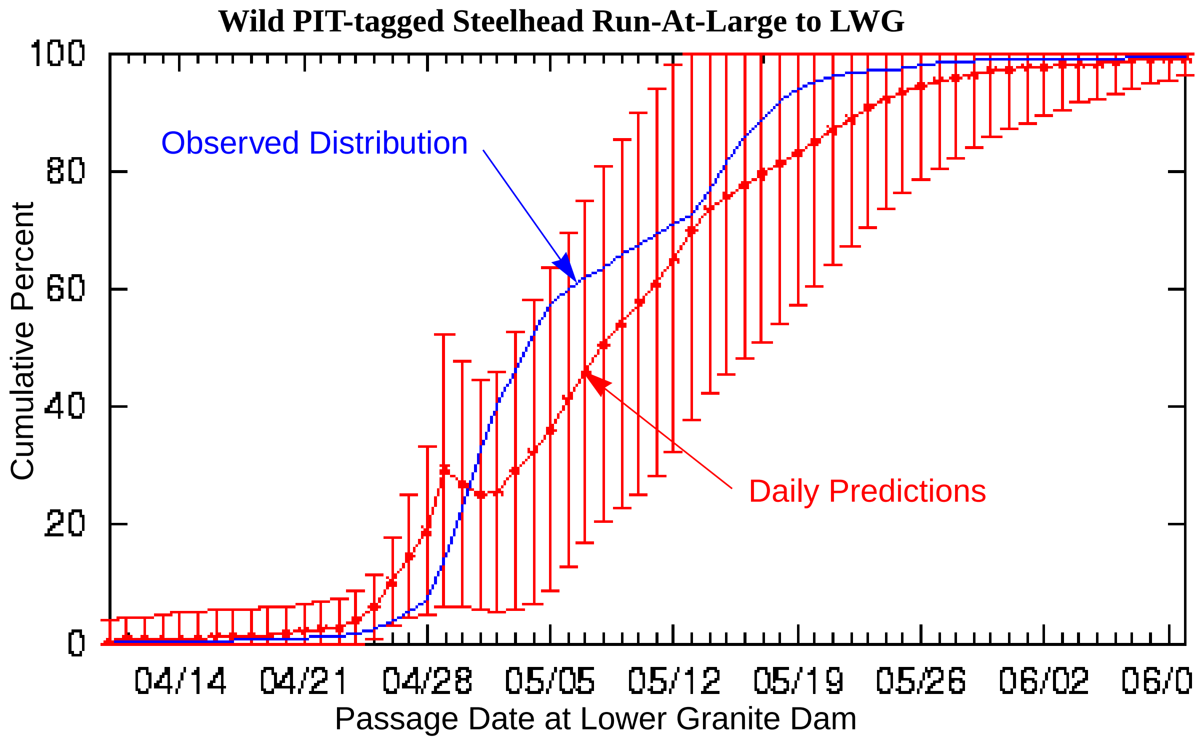


Figure A9: Daily predictions of wild PIT-tagged run-at-large of steelhead at Lower Granite Dam and of the wild PIT-tagged run-at-large of Snake River subyearling chinook salmon at McNary Dam.



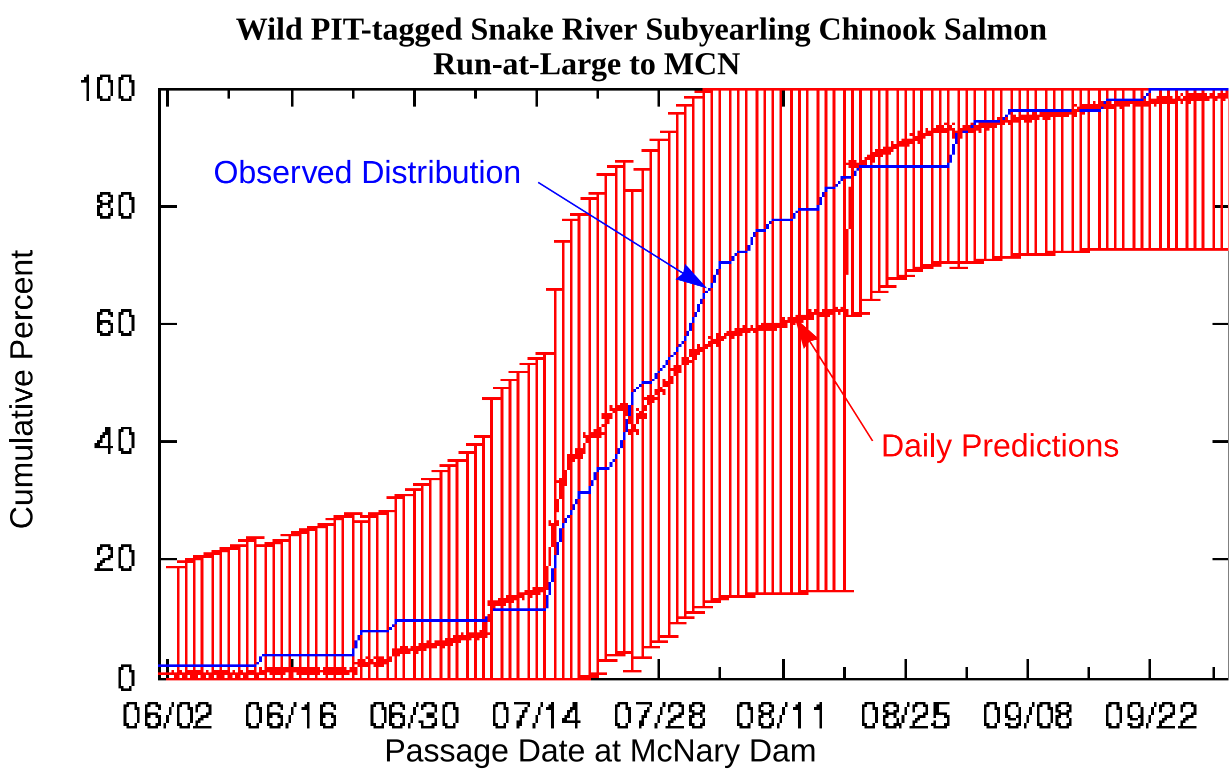
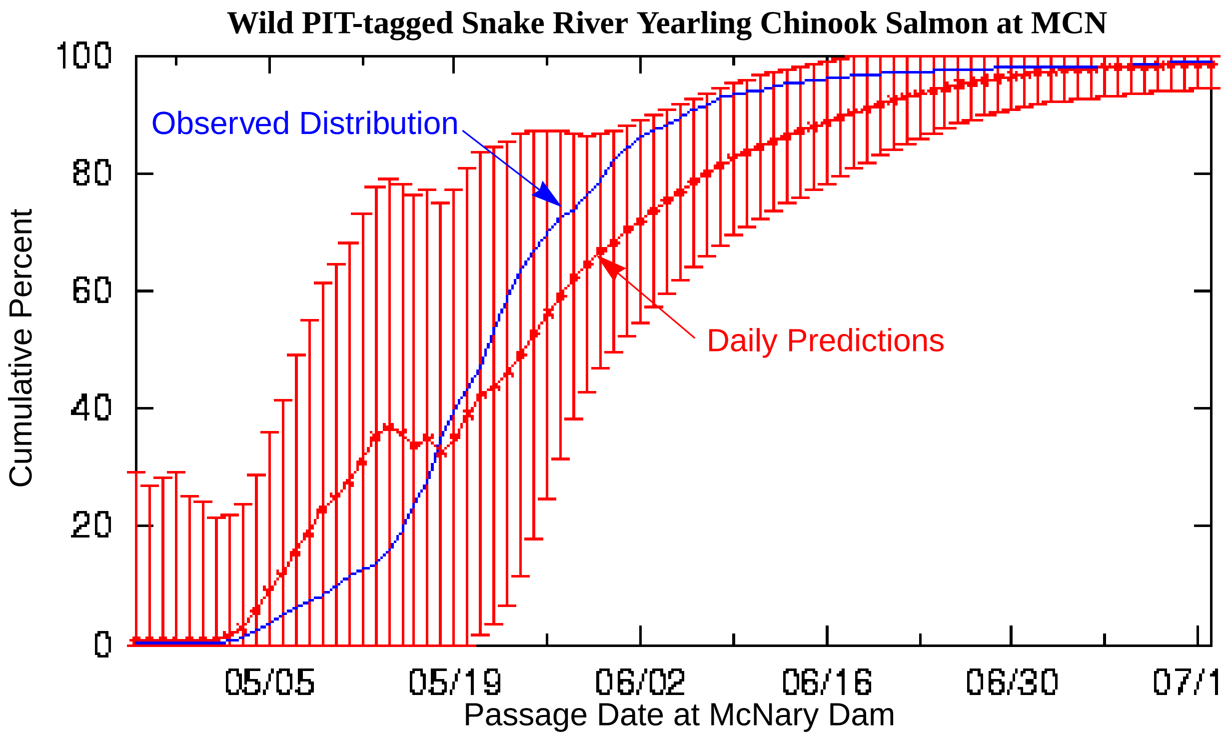


Figure A10: Daily predictions of wild PIT-tagged runs-at-large of Snake River yearling chinook salmon at McNary Dam and of the same stock with predictions based on low-flow years (1992,1994) only.



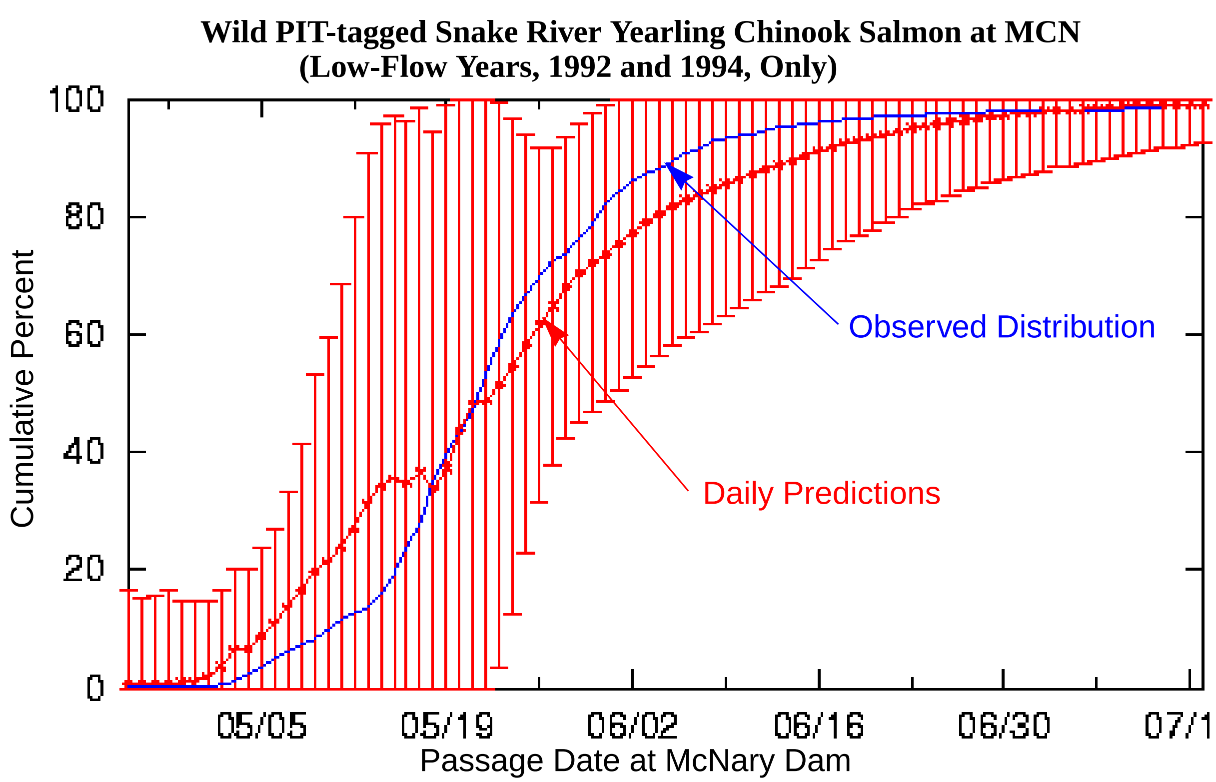
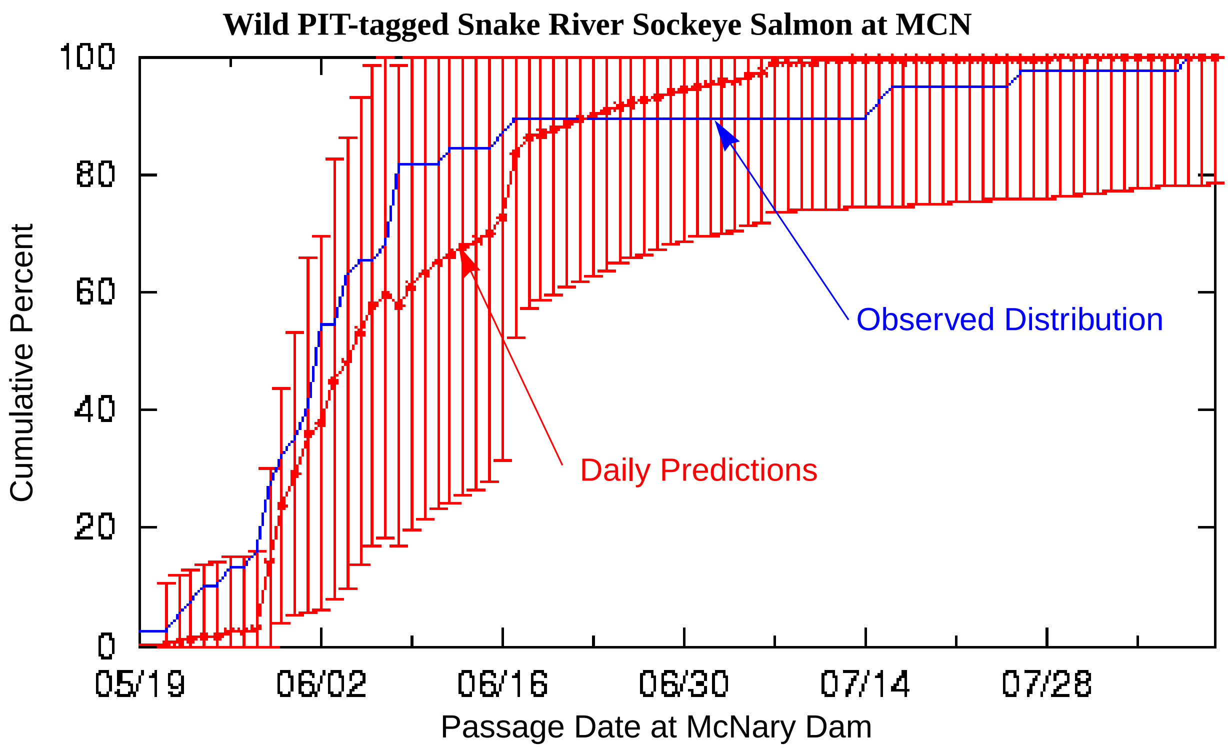


Figure A11: Daily predictions of the wild PIT-tagged runs-at-large of Snake River sockeye salmon and Snake River Steelhead at McNary Dam.



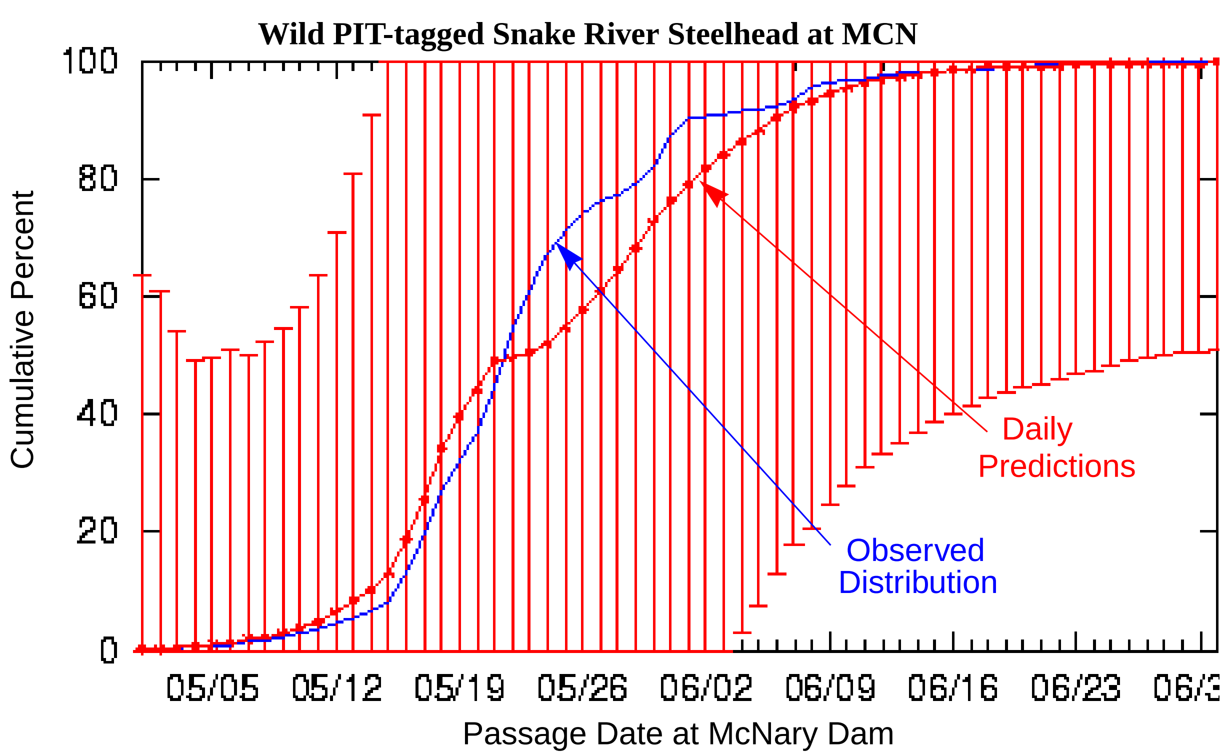
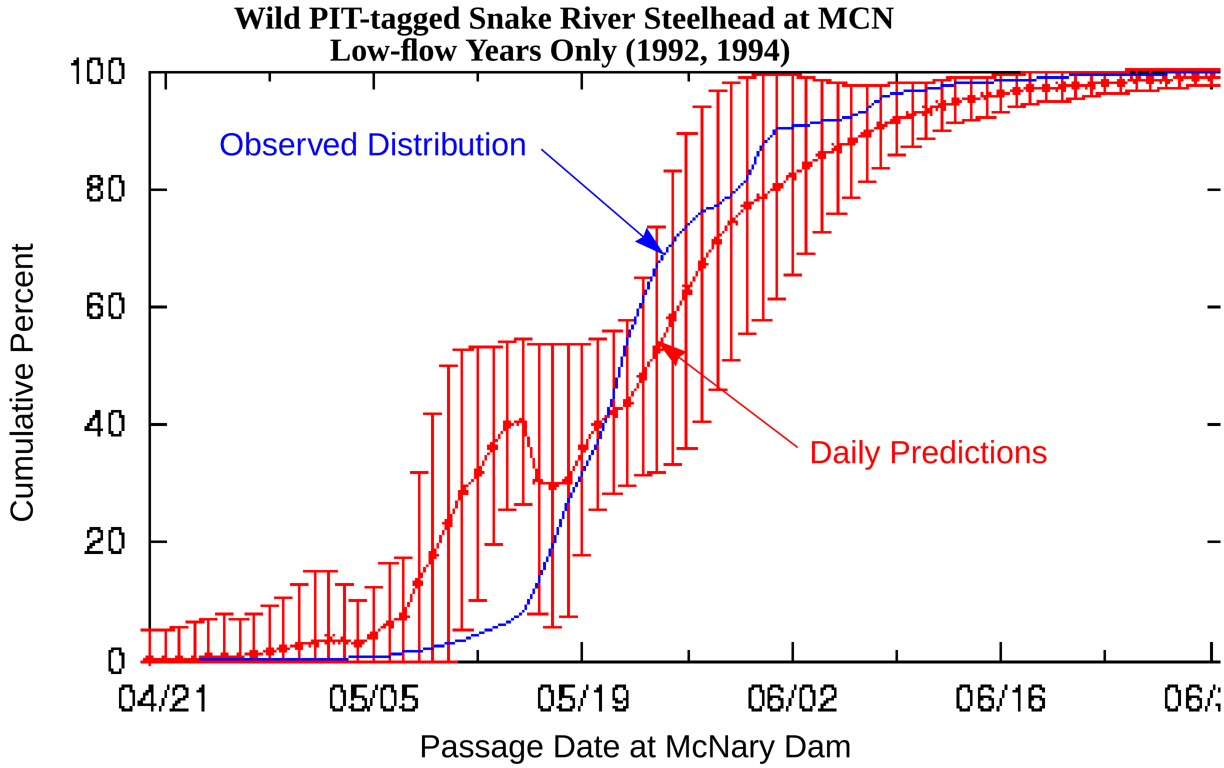


Figure A12: Daily predictions of the wild PIT-tagged runs-at-large of Snake River steelhead (low-flow years, 1992,1994 only) and Upper Columbia River steelhead at McNary Dam.



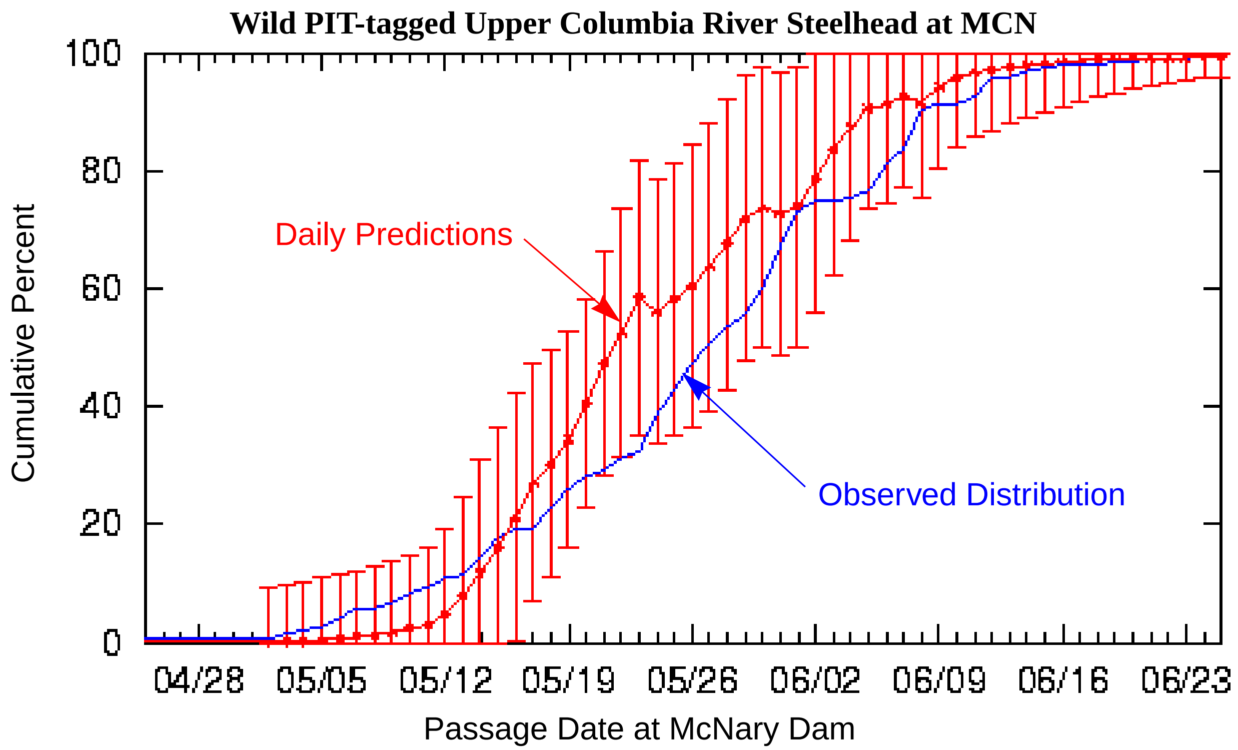
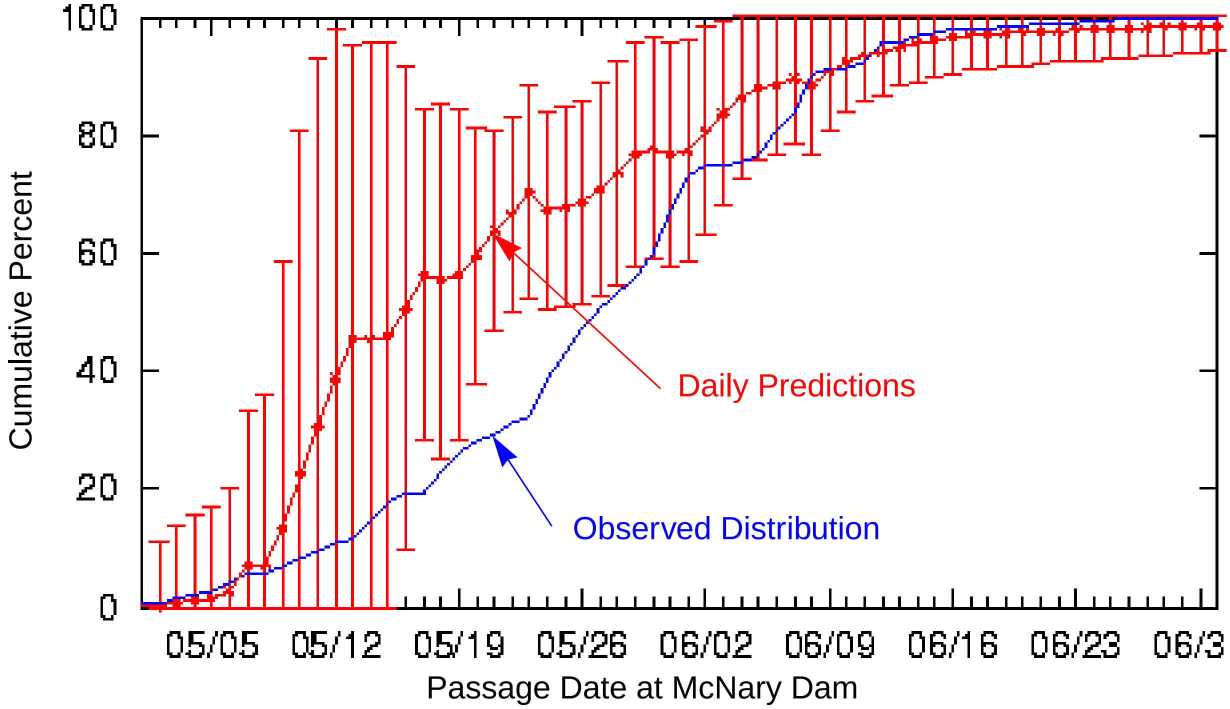


Figure A13: Daily Predictions of the wild, PIT-tagged runs-at-large of Upper Columbia

River steelhead (low-flow years, 1992, 1994 only) and combined Snake and Upper Columbia River steelhead at McNary Dam.

Wild PIT-tagged Upper Columbia River Steelhead at MCN (Low-Flow Years, 1992 and 1994, Only)



Wild PIT-tagged Steelhead at MCN

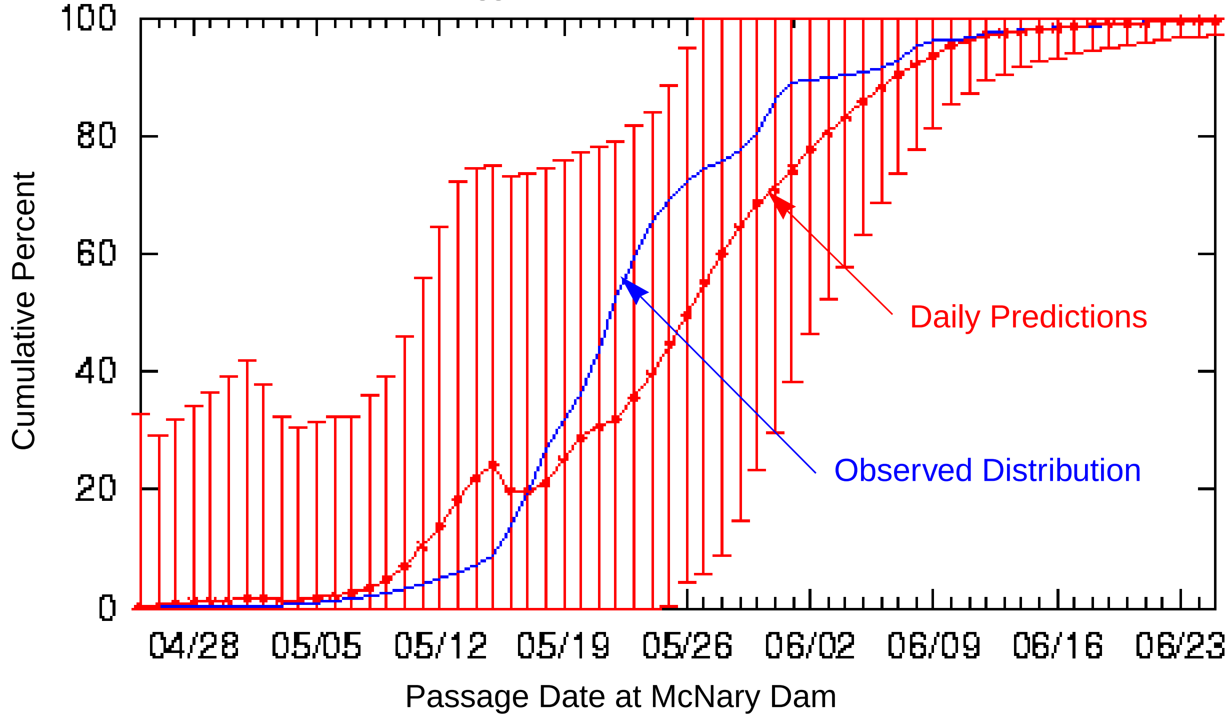
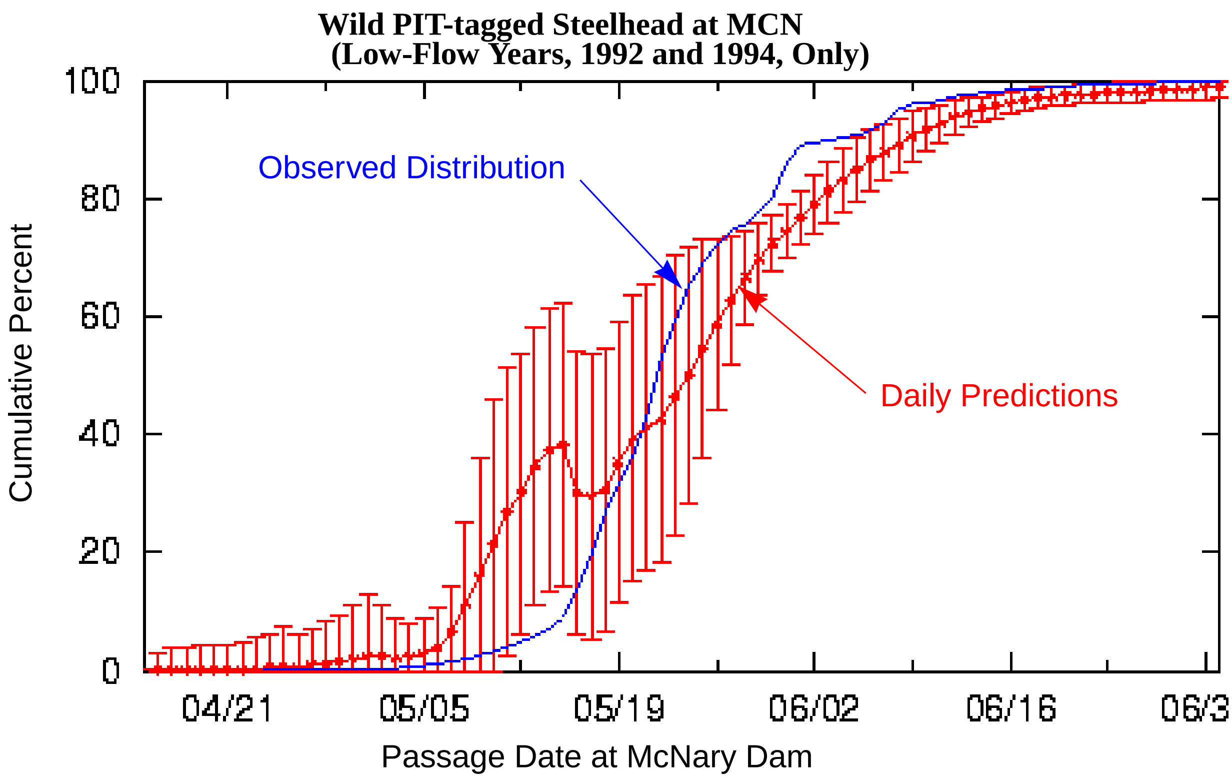


Figure A14: Daily Predictions of the wild, PIT-tagged runs-at-large of combined Snake and

Upper Columbia River steelhead (low-flow years, 1992, 1994 only) and Upper Columbia River subyearling chinook salmon at McNary Dam.



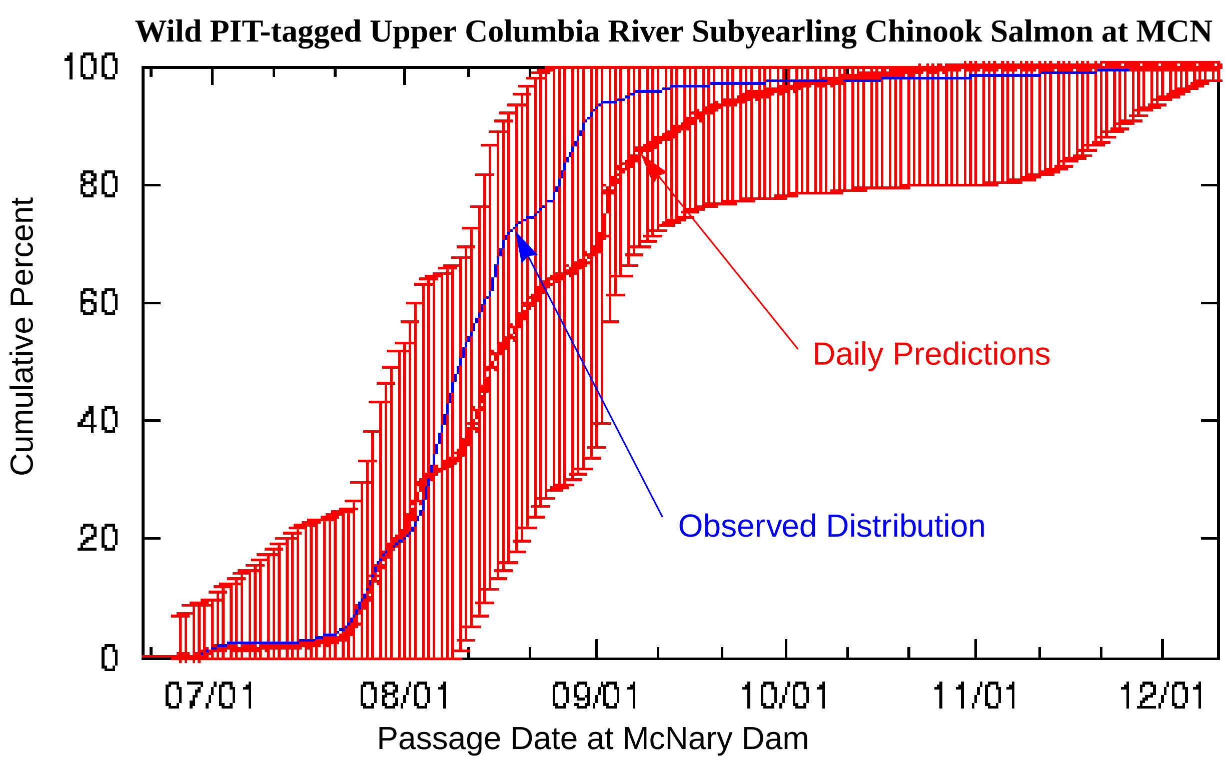
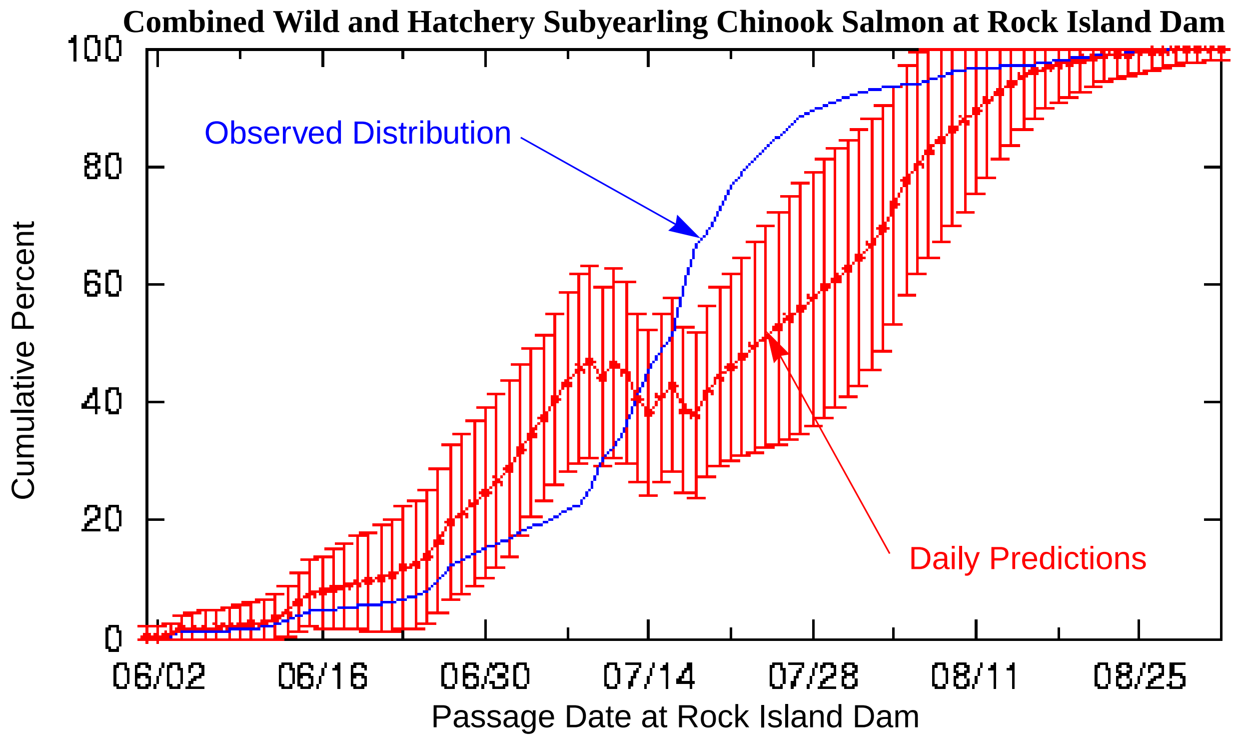


Figure A15: Daily predictions of the wild and hatchery-reared passage-indexed runs-at-

large of subyearling and yearling chinook salmon at Rock Island Dam.



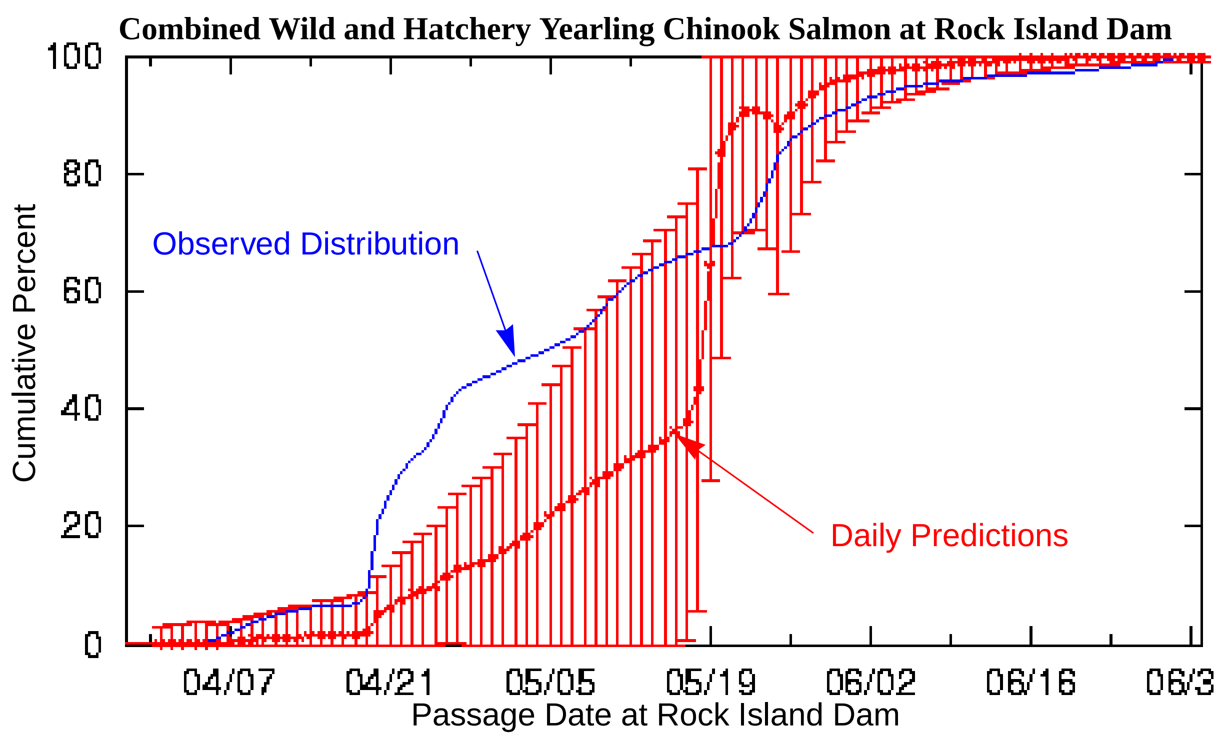
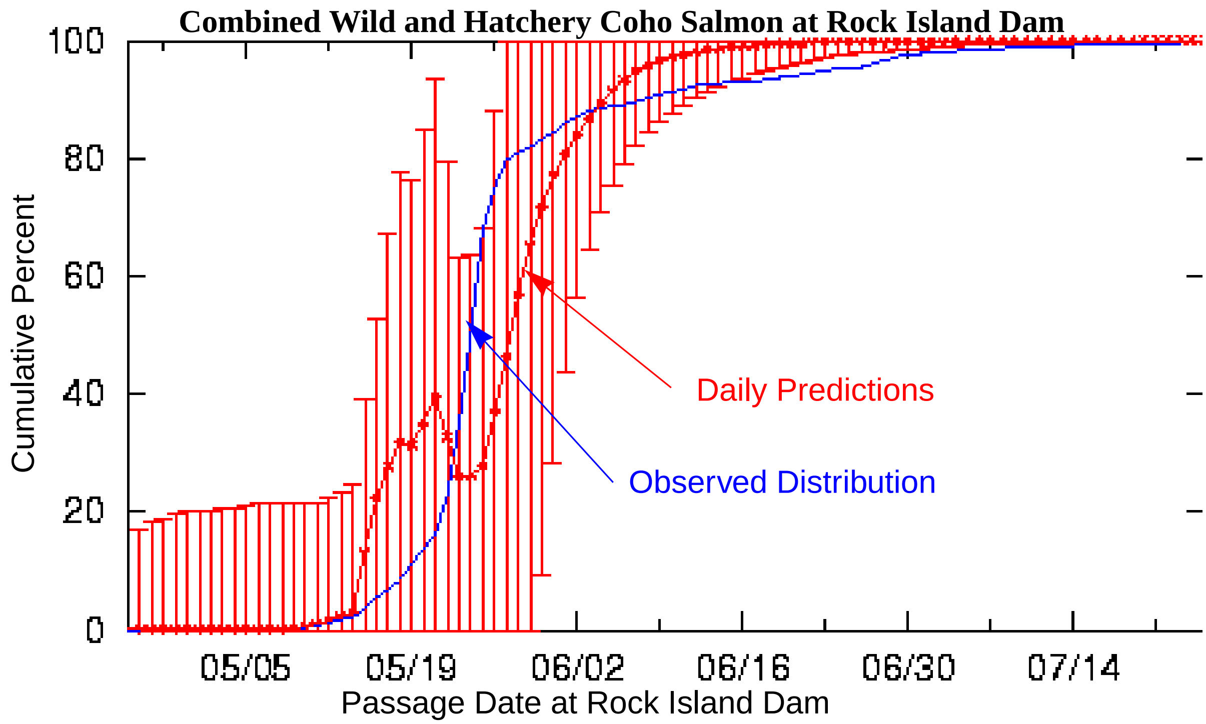


Figure A16: Daily predictions of the wild and hatchery-reared passage-indexed runs-at-

large of coho and sockeye salmon at Rock Island Dam.



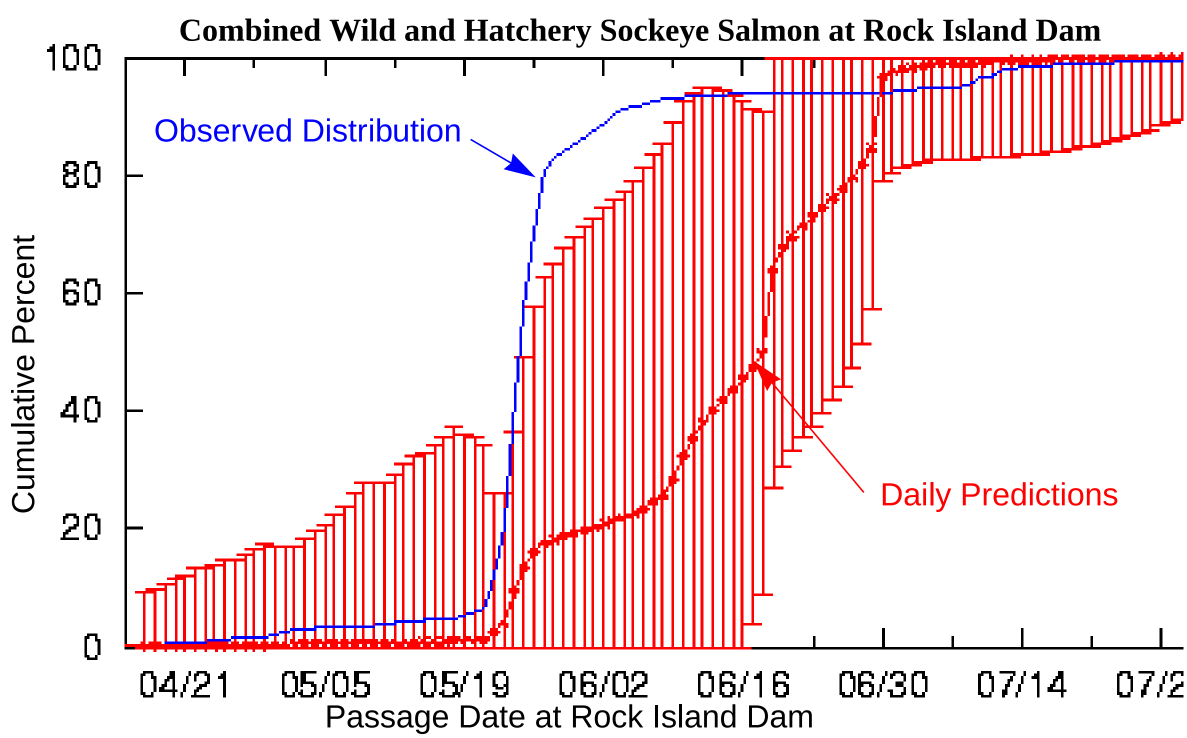
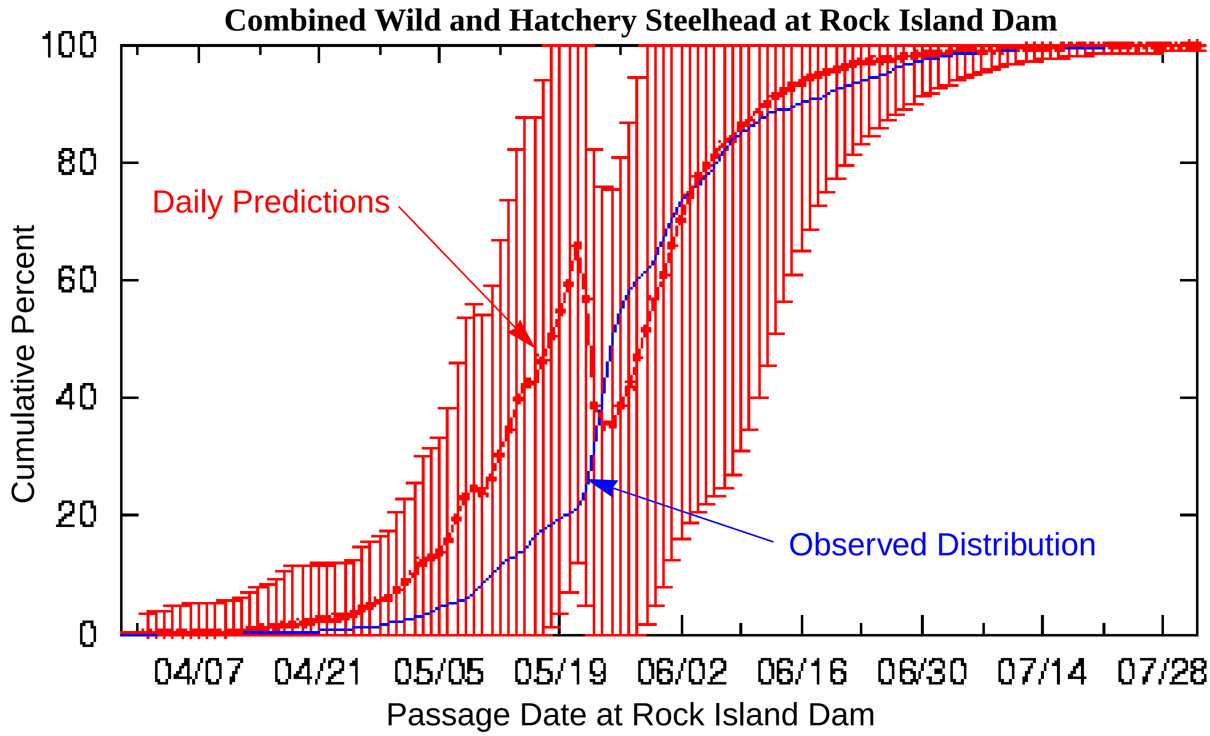


Figure A17: Daily predictions of wild and hatchery-reared passage-indexed runs-at-large of steelhead at Rock Island Dam and subyearling chinook salmon at McNary Dam.



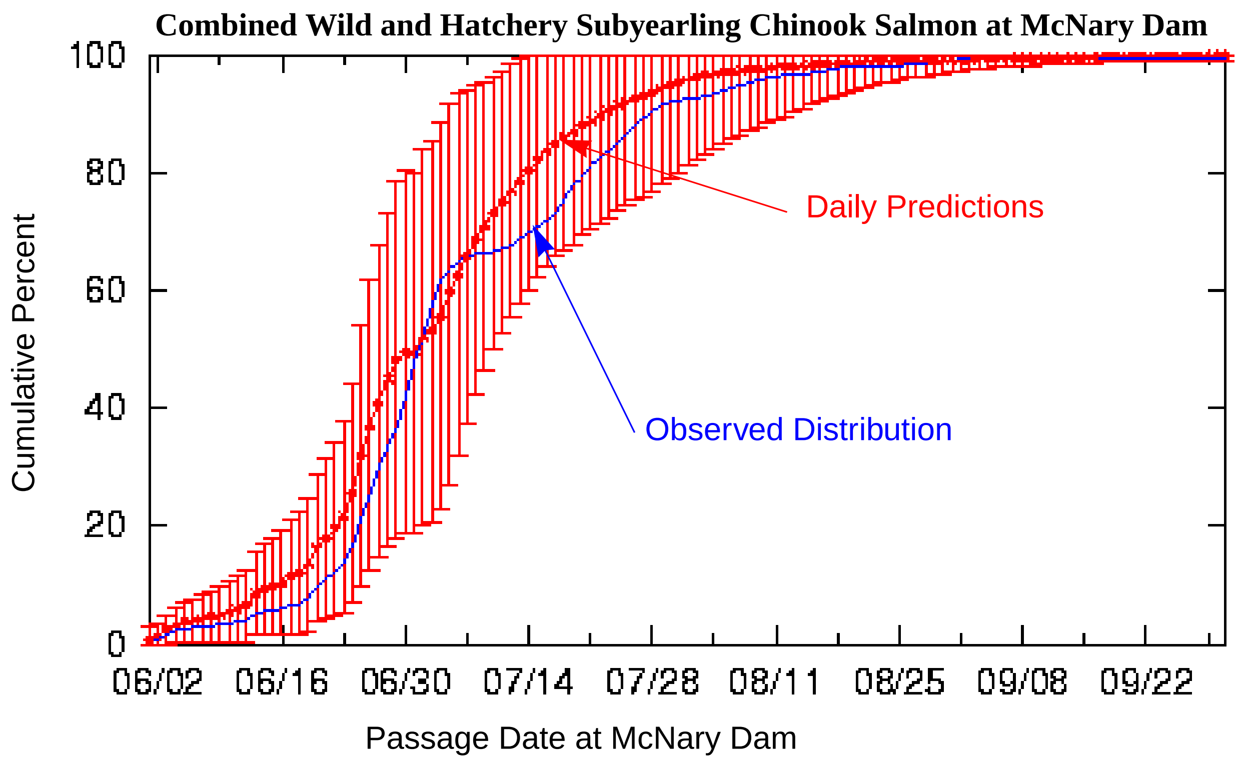
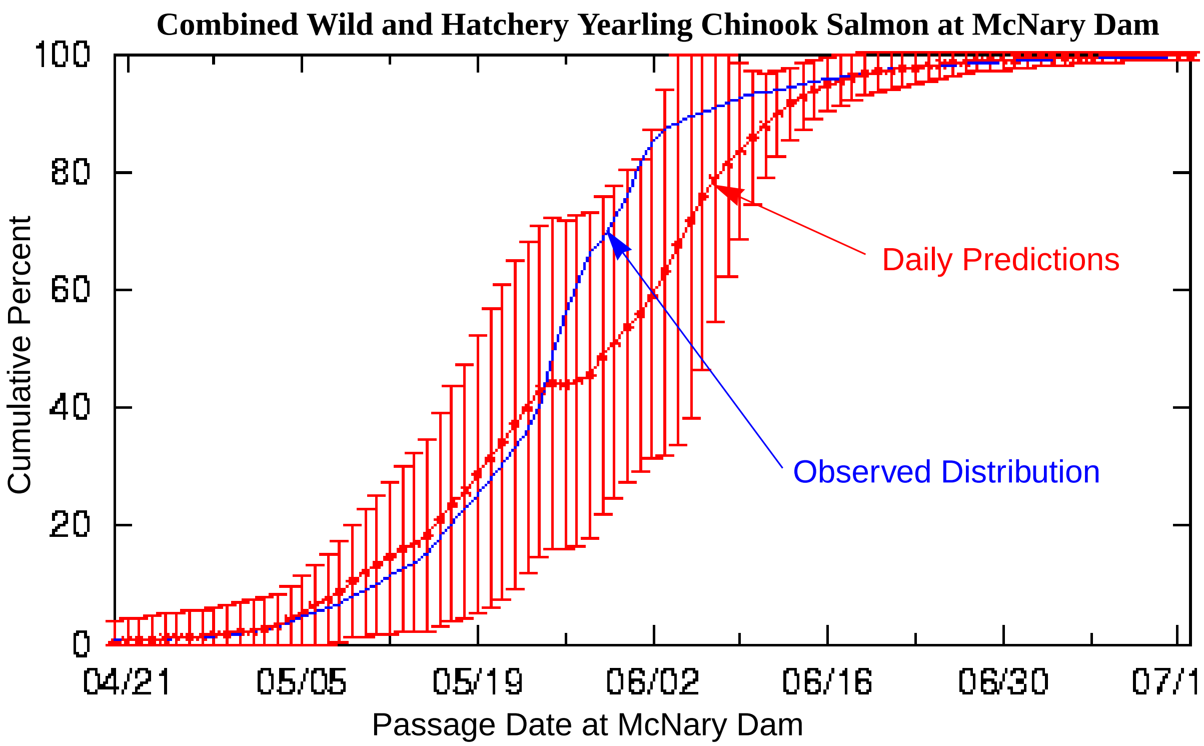


Figure A18: Daily predictions of the wild and hatchery-reared passage-indexed runs-at-large of yearling chinook salmon and coho salmon at McNary Dam.



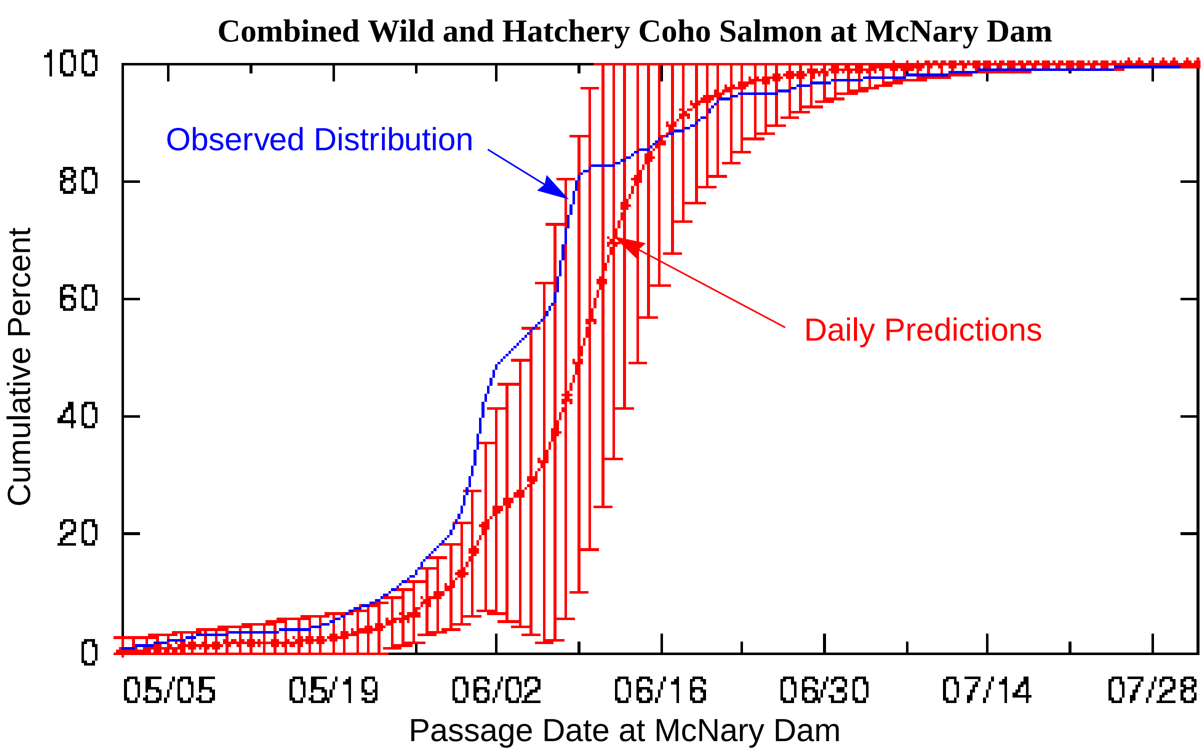
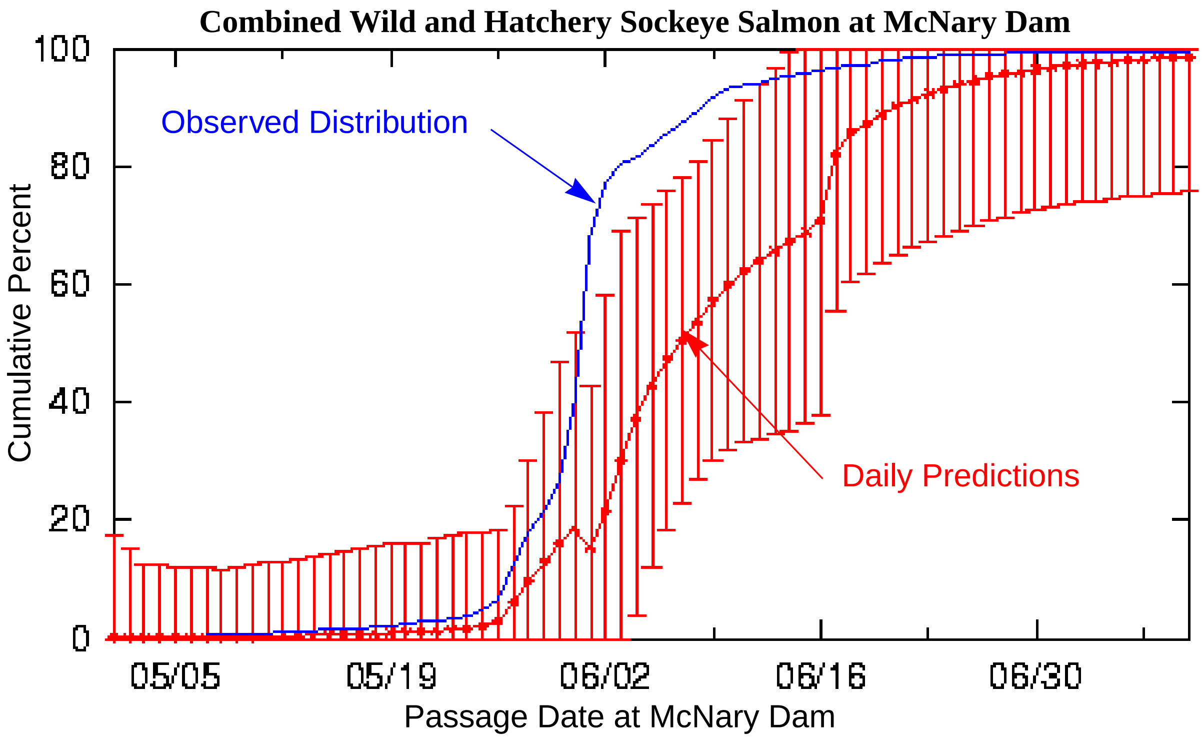


Figure A19: Daily predictions of the wild and hatchery-reared passage-indexed runs-at-large of sockeye salmon and steelhead at McNary Dam.



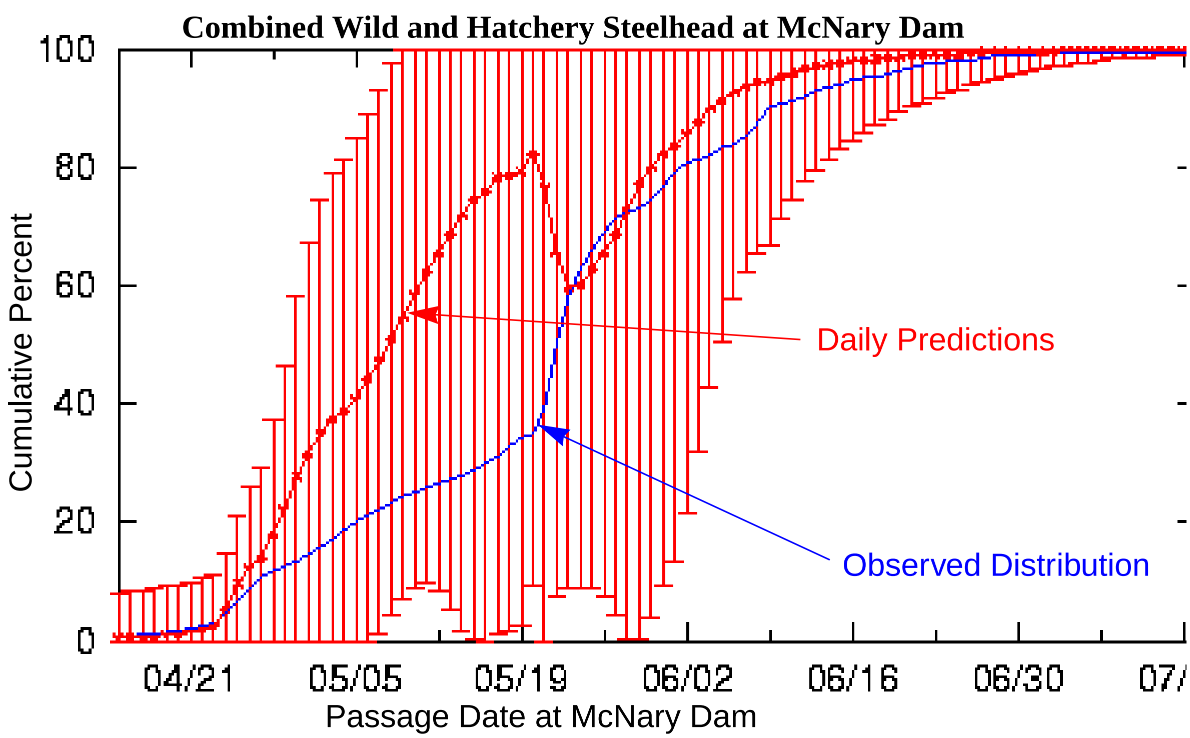
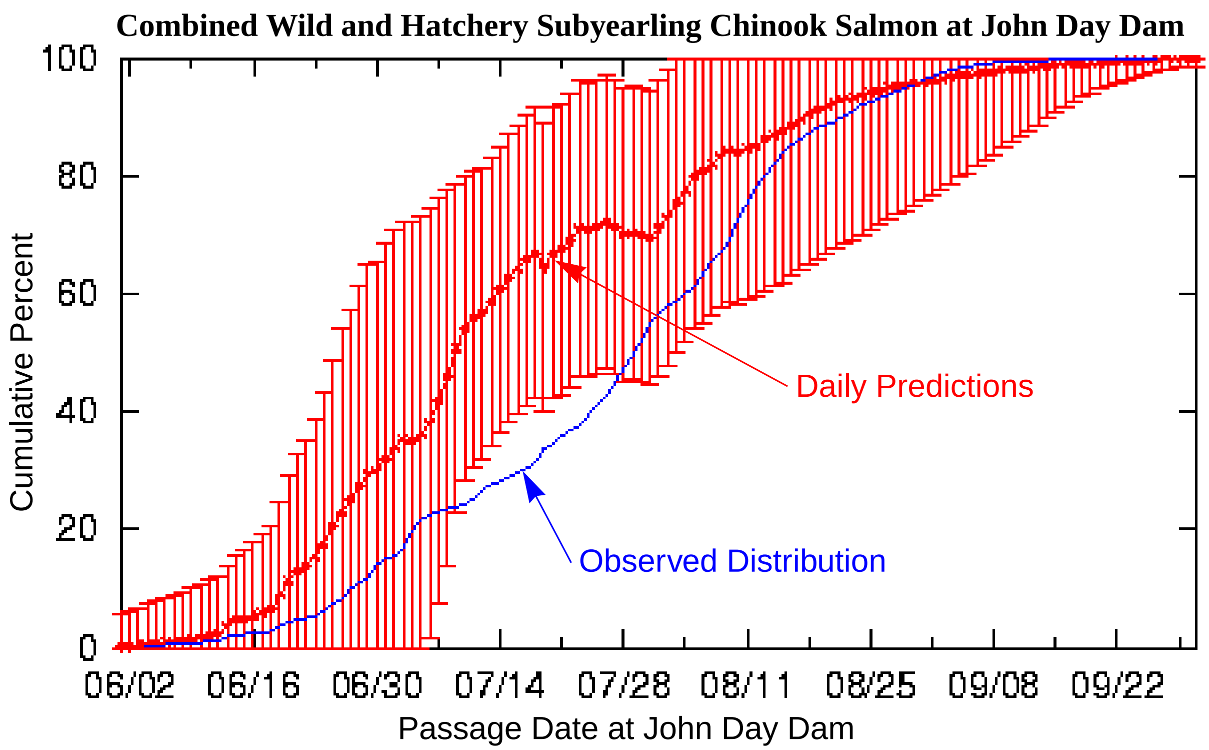


Figure A20: Daily predictions of the wild and hatchery-reared passage-indexed run-at-large of subyearling chinook salmon at John Day Dam.



Appendix B

Historical timing plots and dates of passage at Lower Granite Dam, Rock Island Dam, McNary Dam and John Day Dam for individual stocks tracked and forecasted by Program RealTime during the 2001 outmigration. Stocks tracked at Lower Granite Dam were wild PIT-tagged yearling and subyearling chinook salmon and steelhead trout ESUs, and a hatchery-reared PIT-tagged sockeye salmon ESU. Stocks tracked McNary were wild PIT-tagged yearling and subyearling chinook salmon, sockeye salmon and steelhead trout ESUs, and FPC passage-indexed runs-at-large of combined wild and hatchery-reared yearling and subyearling chinook salmon, coho and sockeye salmon and steel-head trout. Stocks tracked at Rock Island were FPC passage-indexed runs-at-large of combined wild and hatchery-reared yearling and subyearling chinook salmon, coho and sockeye salmon and steelhead trout. The stock tracked to John Day Dam was the FPC passage-indexed run-at-large of combined wild and hatchery subyearling chinook salmon.

Figure B1: Historical Bear Valley Creek outmigration distribution at Lower Granite Dam.

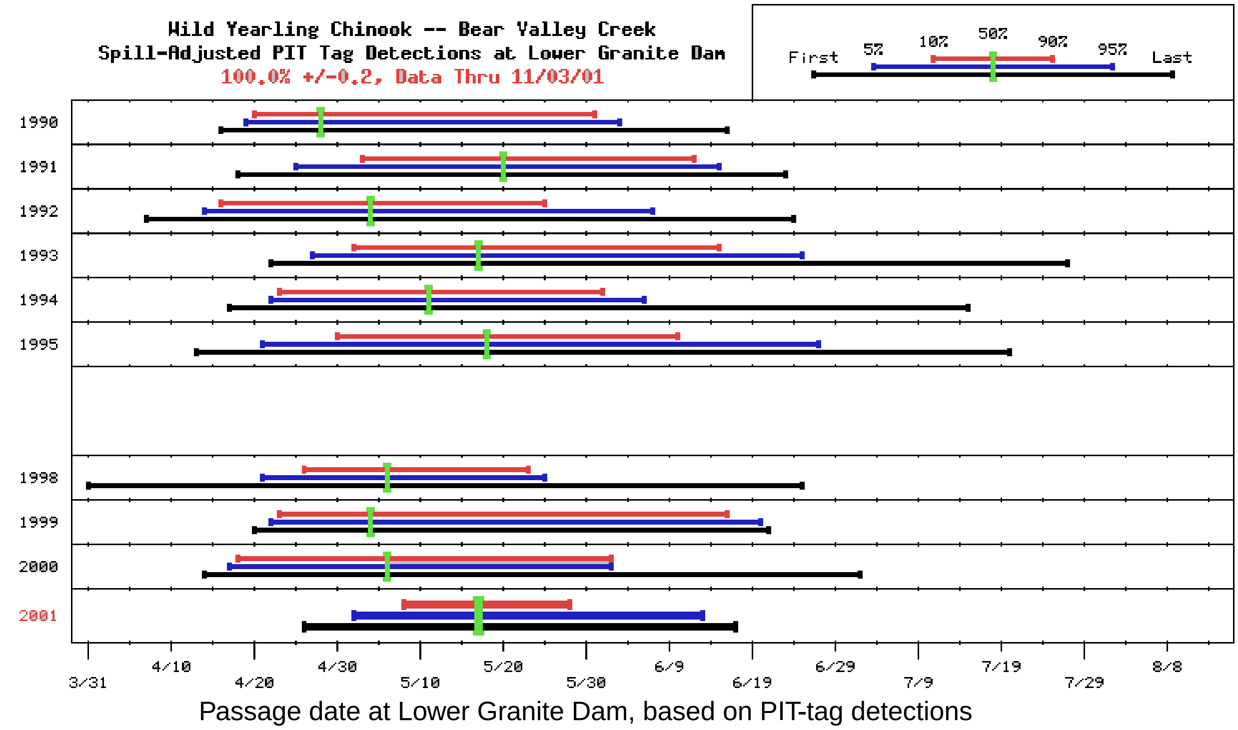


Table B1: Historical Bear Valley Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1990	04/16	04/19	04/20	04/28	05/31	06/03	06/16	42	471	31	31.0	6.6
1991	04/18	04/25	05/03	05/20	06/12	06/15	06/23	41	352	44	44.4	12.6
1992	04/07	04/14	04/16	05/04	05/25	06/07	06/24	40	944	57	57.0	6.0
1993	04/22	04/27	05/02	05/17	06/15	06/25	07/27	45	1015	67	105.1	10.4
1994	04/17	04/22	04/23	05/11	06/01	06/06	07/15	40	856	85	115.4	13.5
1995	04/13	04/21	04/30	05/18	06/10	06/27	07/20	42	1455	74	101.7	7.0
1998	03/31	04/21	04/26	05/06	05/23	05/25	06/25	28	427	59	113.5	26.6
1999	04/20	04/22	04/23	05/04	06/16	06/20	06/21	55	820	39	92.2	11.2
2000	04/14	04/17	04/18	05/06	06/02	06/02	07/02	46	837	44	85.1	10.2
2001	04/26	05/02	05/08	05/17	05/28	06/13	06/17	21	581	112	112.0	19.3

Figure B2: Historical Catherine Creek outmigration distribution at Lower Granite Dam.

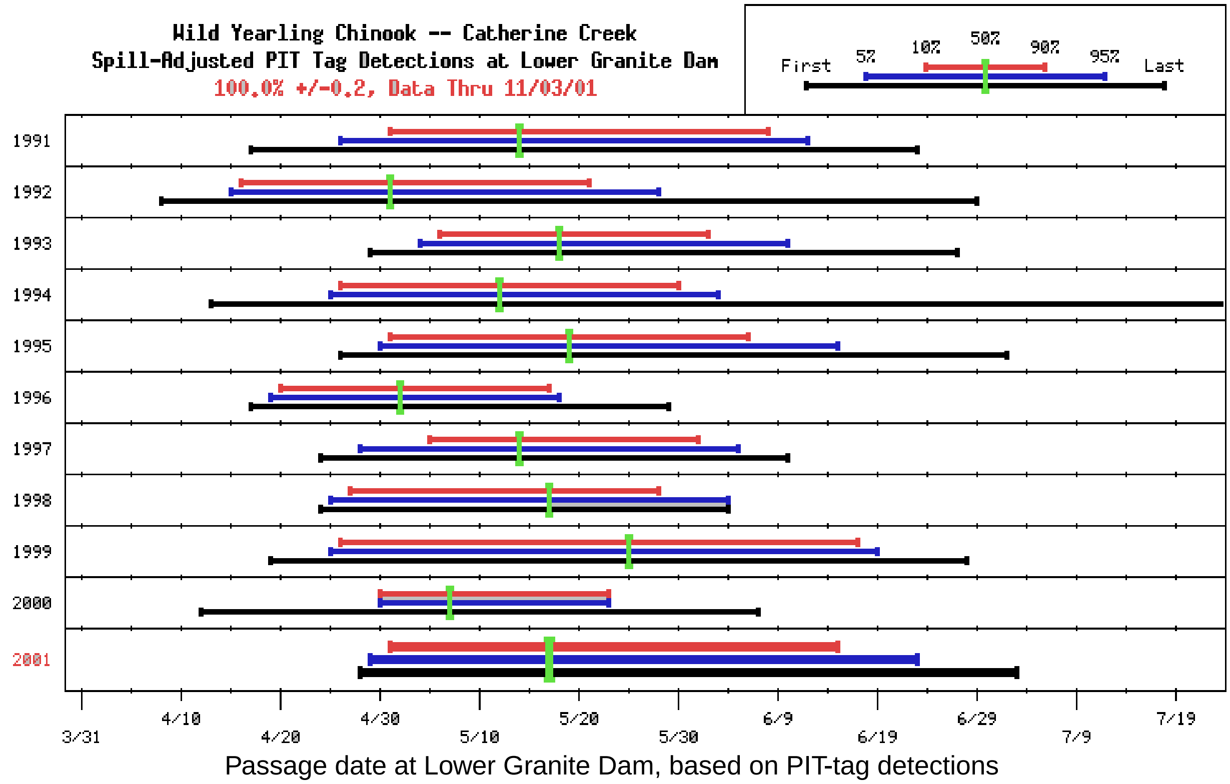
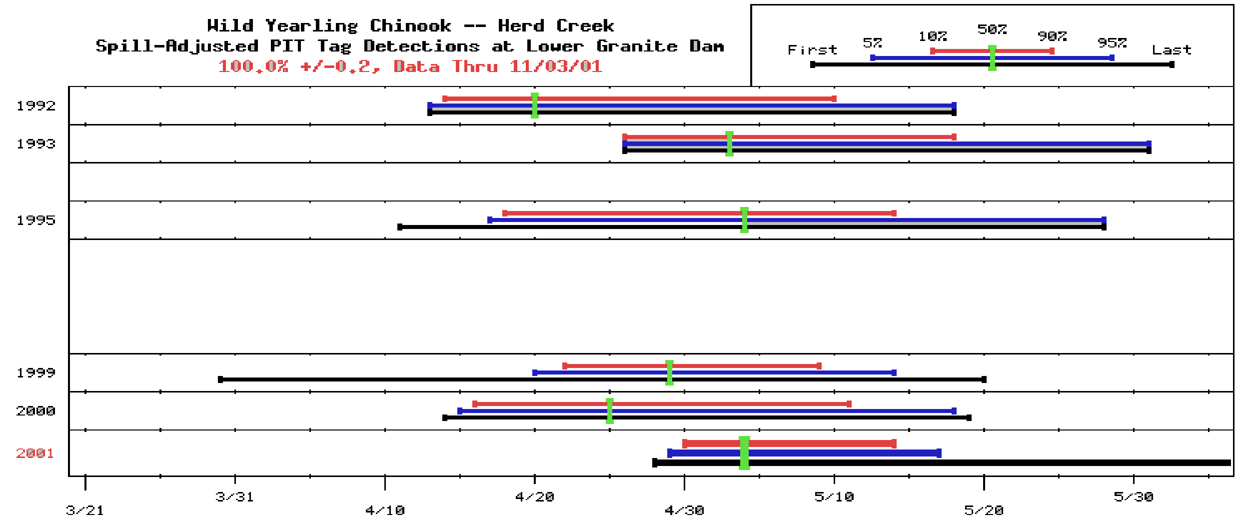


Table B2: Historical Catherine Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1991	04/17	04/26	05/01	05/14	06/08	06/12	06/23	39	1012	77	77.8	7.7
1992	04/08	04/15	04/16	05/01	05/21	05/28	06/29	36	940	67	67.0	7.1
1993	04/29	05/04	05/06	05/18	06/02	06/10	06/27	28	1093	102	158.2	14.5
1994	04/13	04/25	04/26	05/12	05/30	06/03	07/26	35	1000	76	110.5	11.0
1995	04/26	04/30	05/01	05/19	06/06	06/15	07/02	37	1301	115	153.8	11.8
1996	04/17	04/19	04/20	05/02	05/17	05/18	05/29	28	499	40	86.2	17.3
1997	04/24	04/28	05/05	05/14	06/01	06/05	06/10	28	585	51	120.2	20.6
1998	04/24	04/25	04/27	05/17	05/28	06/04	06/04	32	500	43	91.3	18.3
1999	04/19	04/25	04/26	05/25	06/17	06/19	06/28	53	949	44	107.9	11.4
2000	04/12	04/30	04/30	05/07	05/23	05/23	06/07	24	499	30	57.2	11.5
2001	04/28	04/29	05/01	05/17	06/15	06/23	07/03	46	501	33	33.0	6.6

Figure B3: Historical Herd Creek outmigration distribution at Lower Granite Dam.

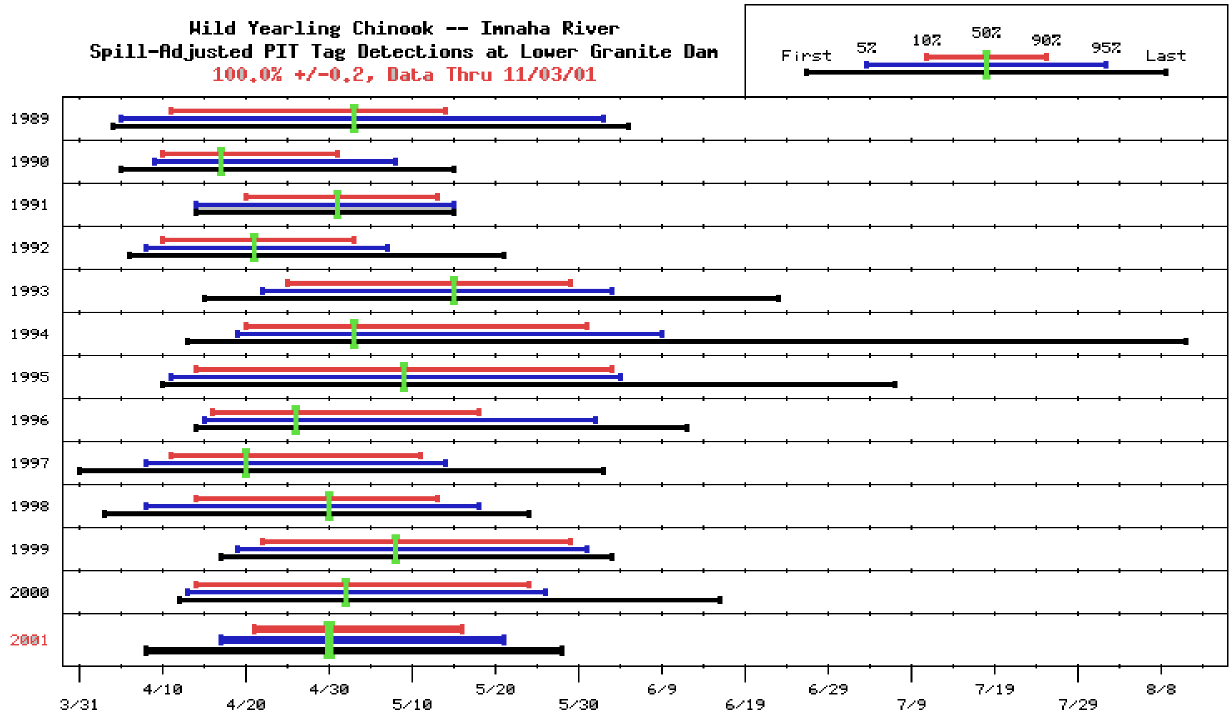


Passage date at Lower Granite Dam, based on PIT-tag detections

Table B3: Historical Herd Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1992	04/13	04/13	04/14	04/20	05/10	05/18	05/18	27	310	17	17.0	5.5
1993	04/26	04/26	04/26	05/03	05/18	05/31	05/31	23	224	16	19.5	8.7
1995	04/11	04/17	04/18	05/04	05/14	05/28	05/28	27	534	36	46.2	8.7
1999	03/30	04/20	04/22	04/29	05/09	05/14	05/20	18	959	58	136.2	14.2
2000	04/14	04/15	04/16	04/25	05/11	05/18	05/19	26	315	23	44.3	14.1
2001	04/28	04/29	04/30	05/04	05/14	05/17	06/07	15	311	66	66.0	21.2

Figure B4: Historical Imnaha River outmigration distribution at Lower Granite Dam.

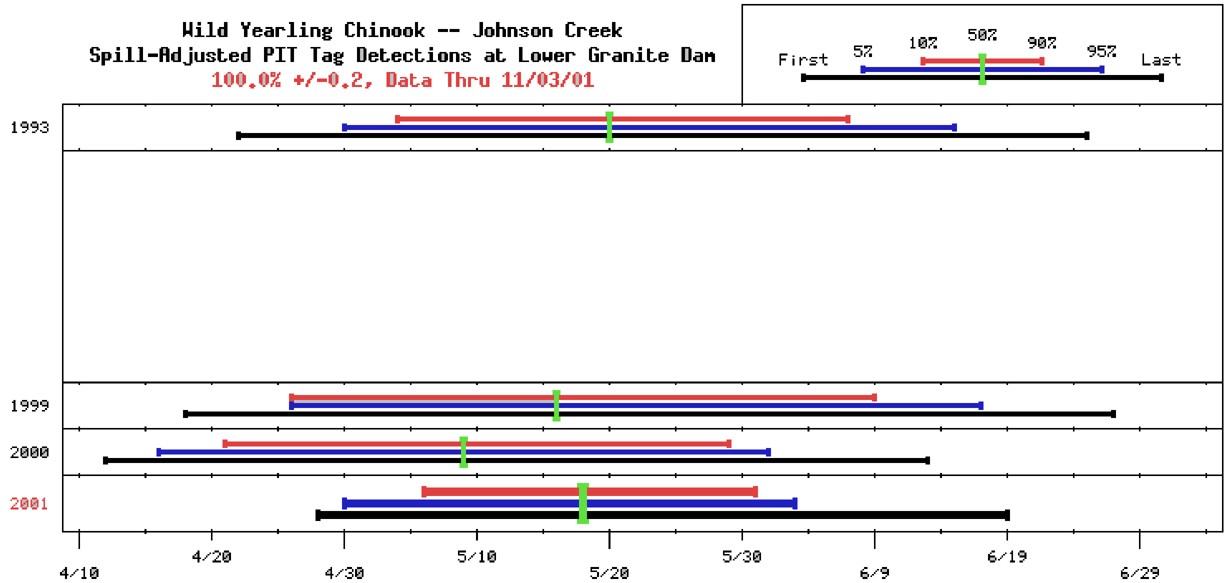


Passage date at Lower Granite Dam, based on PIT-tag detections

Table B4: Historical Imnaha River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/04	04/05	04/11	05/03	05/14	06/02	06/05	34	588	36	36.0	6.1
1990	04/05	04/09	04/10	04/17	05/01	05/08	05/15	22	897	69	69.0	7.7
1991	04/14	04/14	04/20	05/01	05/13	05/15	05/15	24	327	18	18.0	5.5
1992	04/06	04/08	04/10	04/21	05/03	05/07	05/21	24	758	73	73.0	9.6
1993	04/15	04/22	04/25	05/15	05/29	06/03	06/23	35	1003	63	88.3	8.8
1994	04/13	04/19	04/20	05/03	05/31	06/09	08/11	42	1167	91	104.2	8.9
1995	04/10	04/11	04/14	05/09	06/03	06/04	07/07	51	996	40	50.9	5.1
1996	04/14	04/15	04/16	04/26	05/18	06/01	06/12	33	997	97	233.5	23.4
1997	03/31	04/08	04/11	04/20	05/11	05/14	06/02	31	1017	98	191.1	18.8
1998	04/03	04/08	04/14	04/30	05/13	05/18	05/24	30	1010	159	283.5	28.1
1999	04/17	04/19	04/22	05/08	05/29	05/31	06/03	38	1009	41	97.7	9.7
2000	04/12	04/13	04/14	05/02	05/24	05/26	06/16	41	982	63	119.5	12.2
2001	04/08	04/17	04/21	04/30	05/16	05/21	05/28	26	1000	159	159.0	15.9

Figure B5: Historical Johnson Creek outmigration distribution at Lower Granite Dam.

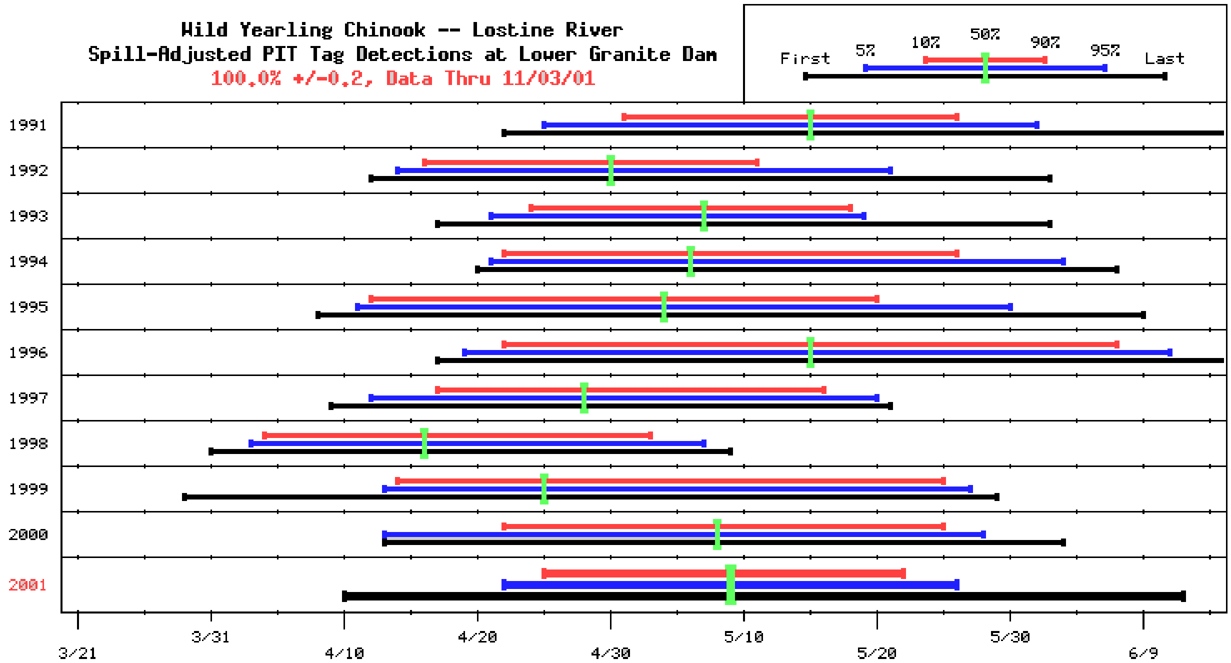


Passage date at Lower Granite Dam, based on PIT-tag detections

Table B5: Historical Johnson Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	04/22	04/30	05/04	05/20	06/07	06/15	06/25	35	634	53	81.0	12.8
1999	04/18	04/26	04/26	05/16	06/09	06/17	06/27	45	1177	58	141.9	12.1
2000	04/12	04/16	04/21	05/09	05/29	06/01	06/13	39	913	49	94.5	10.3
2001	04/28	04/30	05/06	05/18	05/31	06/03	06/19	26	677	134	134.0	19.8

Figure B6: Historical Lostine River outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B6: Historical Lostine River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1991	04/22	04/25	05/01	05/15	05/26	06/01	06/18	26	549	51	51.8	9.4
1992	04/12	04/14	04/16	04/30	05/11	05/21	06/02	26	1107	92	92.0	8.3
1993	04/17	04/21	04/24	05/07	05/18	05/19	06/02	25	999	123	156.1	15.6
1994	04/20	04/21	04/22	05/06	05/26	06/03	06/07	35	725	71	87.4	12.1
1995	04/08	04/11	04/12	05/04	05/20	05/30	06/09	39	1002	112	142.0	14.2
1996	04/17	04/19	04/22	05/15	06/07	06/11	06/19	47	978	81	188.2	19.2
1997	04/09	04/12	04/17	04/28	05/16	05/20	05/21	30	527	43	93.0	17.6
1998	03/31	04/03	04/04	04/16	05/03	05/07	05/09	30	236	46	70.5	29.9
1999	03/29	04/13	04/14	04/25	05/25	05/27	05/29	42	823	44	106.6	13.0
2000	04/13	04/13	04/22	05/08	05/25	05/28	06/03	34	509	36	68.8	13.5
2001	04/10	04/22	04/25	05/09	05/22	05/26	06/12	28	489	87	87.0	17.8

Figure B7: Historical Minam River outmigration distribution at Lower Granite Dam.

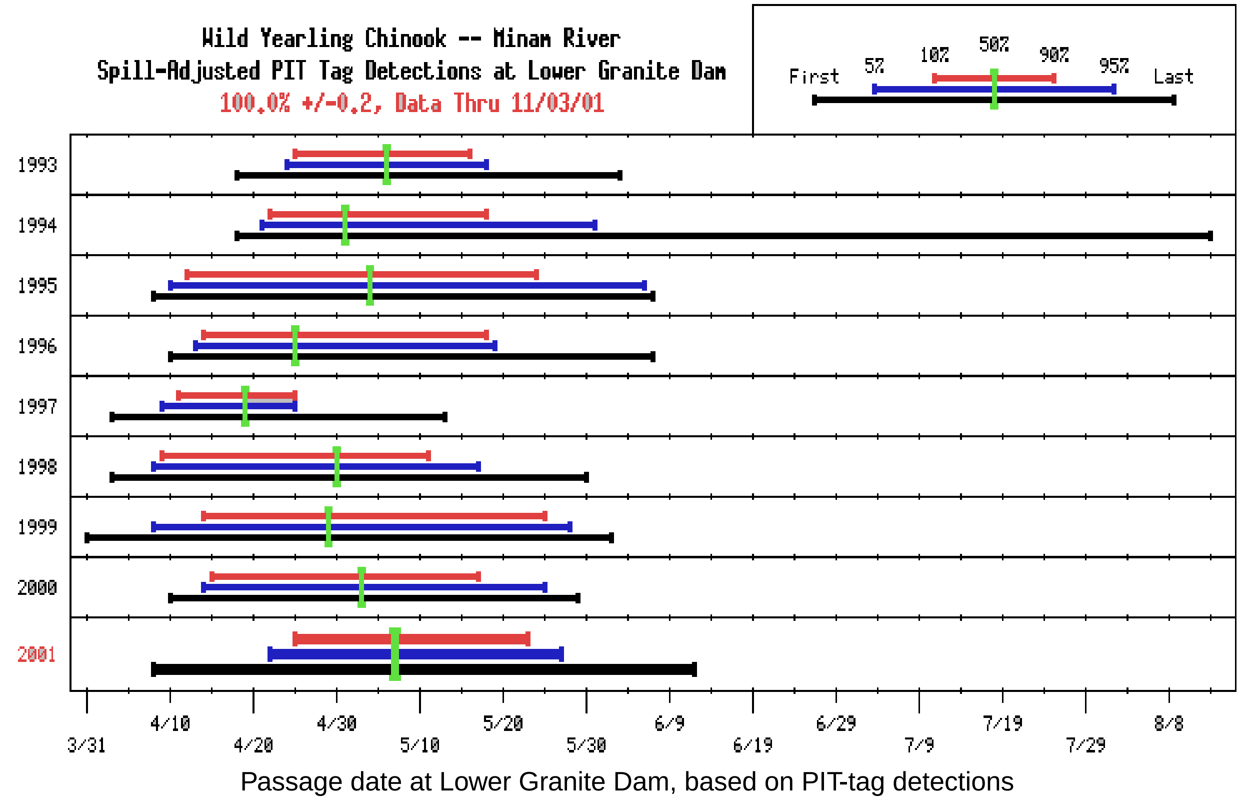


Table B7: Historical Minam River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	04/18	04/24	04/25	05/06	05/16	05/18	06/03	22	1000	105	125.5	12.5
1994	04/18	04/21	04/22	05/01	05/18	05/31	08/13	27	997	112	133.3	13.4
1995	04/08	04/10	04/12	05/04	05/24	06/06	06/07	43	996	70	89.3	9.0
1996	04/10	04/13	04/14	04/25	05/18	05/19	06/07	35	998	68	164.9	16.5
1997	04/03	04/09	04/11	04/19	04/25	04/25	05/13	15	589	49	92.4	15.7
1998	04/03	04/08	04/09	04/30	05/11	05/17	05/30	33	998	123	221.8	22.2
1999	03/31	04/08	04/14	04/29	05/25	05/28	06/02	42	1006	51	120.4	12.0
2000	04/10	04/14	04/15	05/03	05/17	05/25	05/29	33	998	74	142.1	14.2
2001	04/08	04/22	04/25	05/07	05/23	05/27	06/12	29	1000	178	178.0	17.8

Figure B8: Historical Salmon River, SF outmigration distribution at Lower Granite Dam.

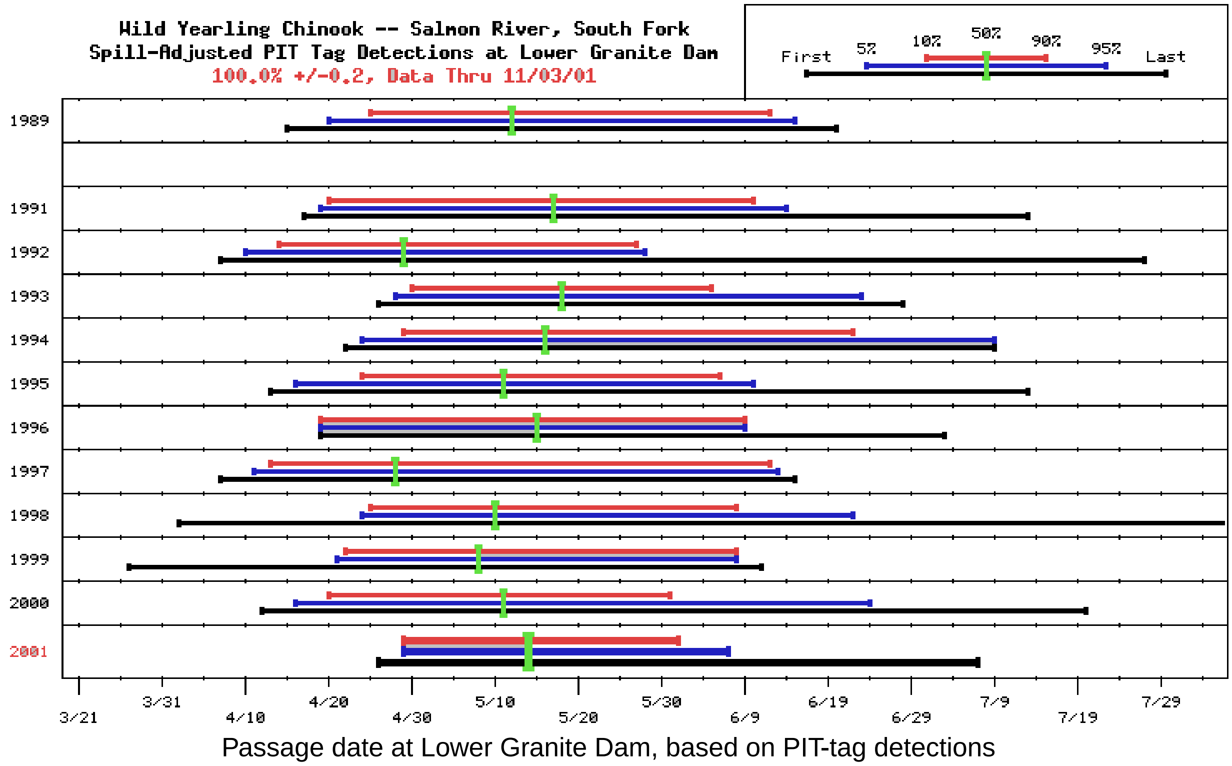


Table B8: Historical Salmon River, SF outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/15	04/20	04/25	05/12	06/12	06/15	06/20	49	2178	84	84.0	3.9
1991	04/17	04/19	04/20	05/17	06/10	06/14	07/13	52	986	98	98.8	10.0
1992	04/07	04/10	04/14	04/29	05/27	05/28	07/27	44	1027	81	81.0	7.9
1993	04/26	04/28	04/30	05/18	06/05	06/23	06/28	37	723	48	79.4	11.0
1994	04/22	04/24	04/29	05/16	06/22	07/09	07/09	55	803	41	58.1	7.2
1995	04/13	04/16	04/24	05/11	06/06	06/10	07/13	44	1571	78	105.2	6.7
1996	04/19	04/19	04/19	05/15	06/09	06/09	07/03	52	700	16	37.2	5.3
1997	04/07	04/11	04/13	04/28	06/12	06/13	06/15	61	700	36	78.9	11.3
1998	04/02	04/24	04/25	05/10	06/08	06/22	08/07	45	1007	83	155.5	15.4
1999	03/27	04/21	04/22	05/08	06/08	06/08	06/11	48	998	38	87.6	8.8
2000	04/12	04/16	04/20	05/11	05/31	06/24	07/20	42	1010	39	72.0	7.1
2001	04/26	04/29	04/29	05/14	06/01	06/07	07/07	34	1010	116	116.0	11.5

Figure B9: Historical Secesh River outmigration distribution at Lower Granite Dam.

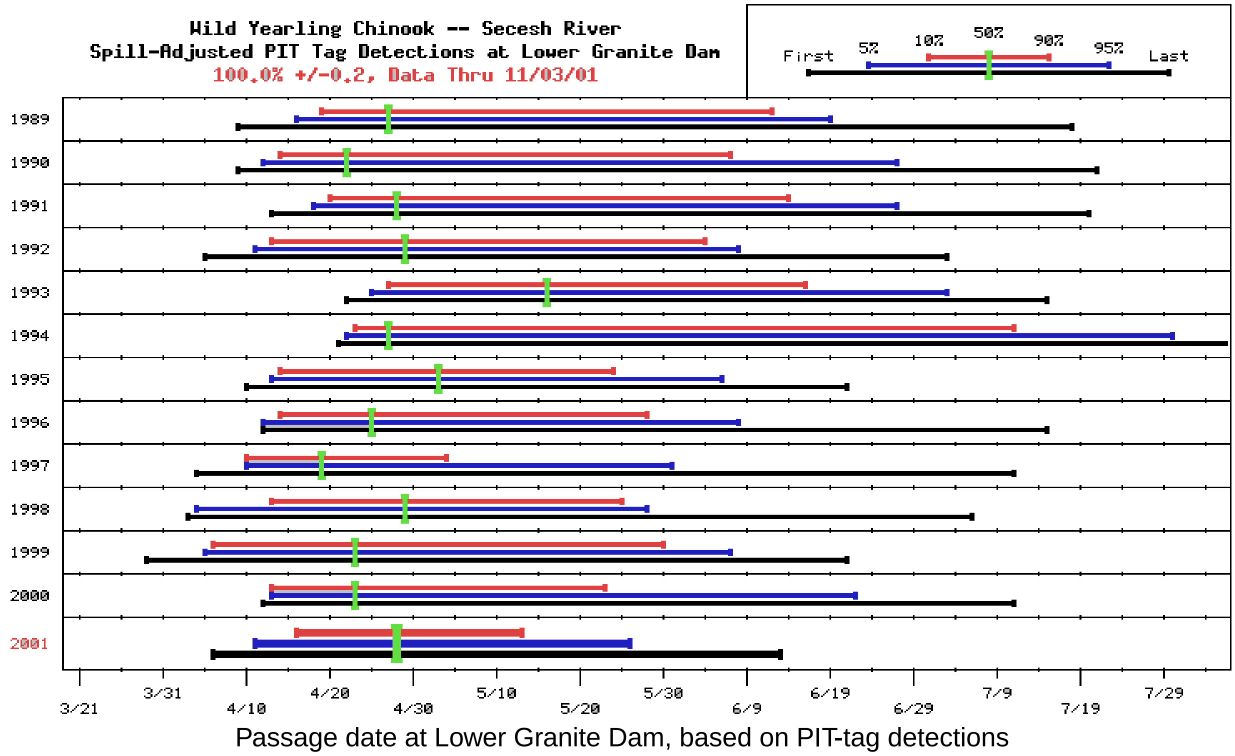
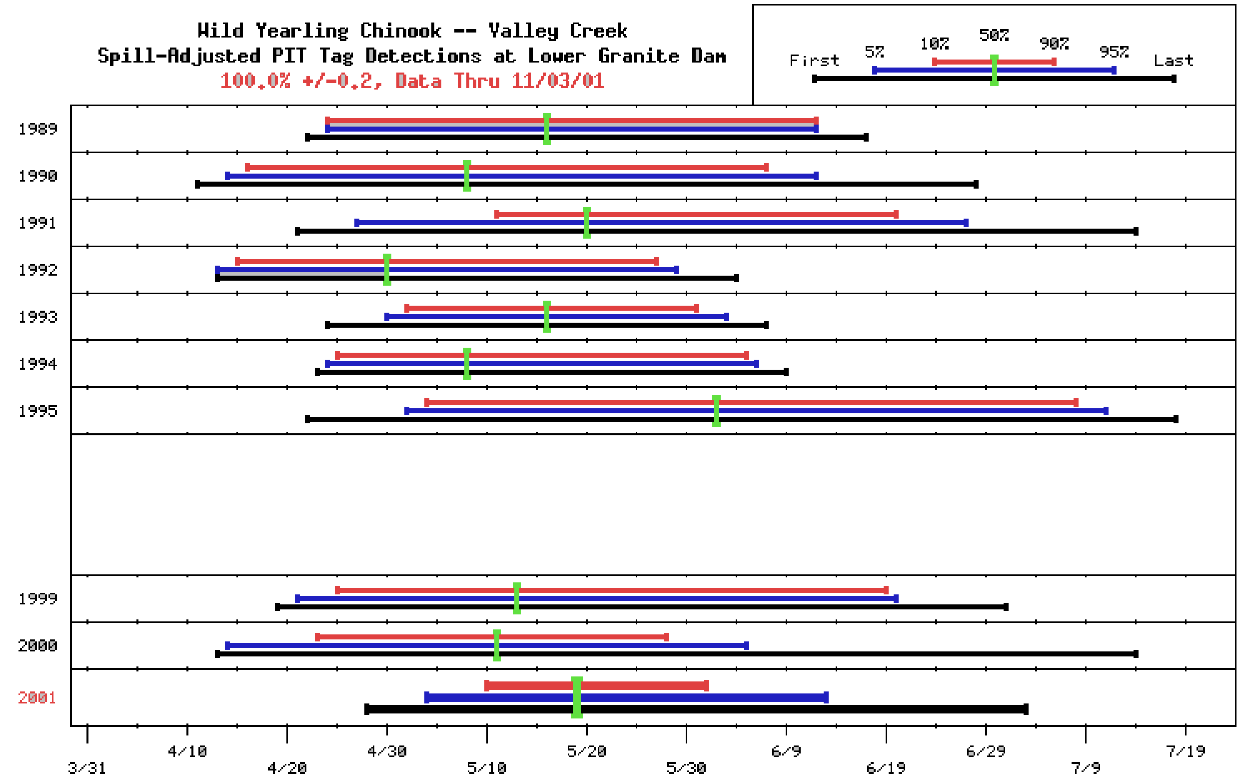


Table B9: Historical Secesh River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/09	04/16	04/19	04/27	06/12	06/19	07/18	55	1507	142	142.0	9.4
1990	04/09	04/12	04/14	04/22	06/07	06/27	07/21	55	1545	108	108.0	7.0
1991	04/13	04/18	04/20	04/28	06/14	06/27	07/20	56	1016	71	72.3	7.1
1992	04/05	04/11	04/13	04/29	06/04	06/08	07/03	53	1012	40	40.0	4.0
1993	04/22	04/25	04/27	05/16	06/16	07/03	07/15	51	327	30	37.0	11.3
1994	04/21	04/22	04/23	04/27	07/11	07/30	08/07	80	422	32	33.0	7.8
1995	04/10	04/13	04/14	05/03	05/24	06/06	06/21	41	1213	74	90.6	7.5
1996	04/12	04/12	04/14	04/25	05/28	06/08	07/15	45	571	26	70.0	12.3
1997	04/04	04/10	04/10	04/19	05/04	05/31	07/11	25	260	34	62.7	24.1
1998	04/03	04/04	04/13	04/29	05/25	05/28	07/06	43	588	74	126.1	21.4
1999	03/29	04/05	04/06	04/23	05/30	06/07	06/21	55	936	36	80.4	8.6
2000	04/12	04/13	04/13	04/23	05/23	06/22	07/11	41	907	40	74.2	8.2
2001	04/06	04/11	04/16	04/28	05/13	05/26	06/13	28	586	169	169.0	28.8

Figure B10: Historical Valley Creek outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B10: Historical Valley Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/22	04/24	04/24	05/16	06/12	06/12	06/17	50	1241	43	43.0	3.5
1990	04/11	04/14	04/16	05/08	06/07	06/12	06/28	53	2496	76	76.0	3.0
1991	04/21	04/27	05/11	05/20	06/20	06/27	07/14	41	1024	41	41.0	4.0
1992	04/13	04/13	04/15	04/30	05/27	05/29	06/04	43	969	34	34.0	3.5
1993	04/24	04/30	05/02	05/16	05/31	06/03	06/07	30	1026	32	51.2	5.0
1994	04/23	04/24	04/25	05/08	06/05	06/06	06/09	42	848	45	61.8	7.3
1995	04/22	05/02	05/04	06/02	07/08	07/11	07/18	66	1551	50	64.0	4.1
1999	04/19	04/21	04/25	05/13	06/19	06/20	07/01	56	1001	50	118.3	11.8
2000	04/13	04/14	04/23	05/11	05/28	06/05	07/14	36	1009	51	95.7	9.5
2001	04/28	05/04	05/10	05/19	06/01	06/13	07/03	23	1004	135	135.0	13.4

Figure B11: Historical PIT-tagged Run-at-Large of Wild Yearling Chinook Salmon outmigration distribution at Lower Granite Dam.

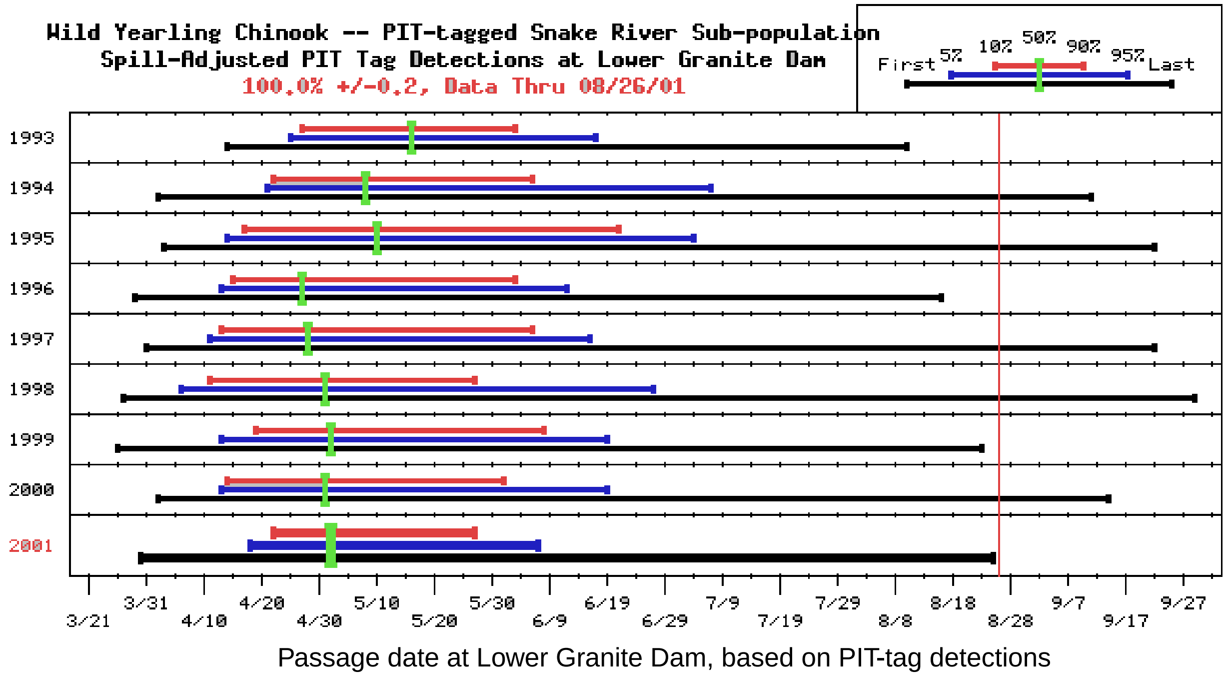
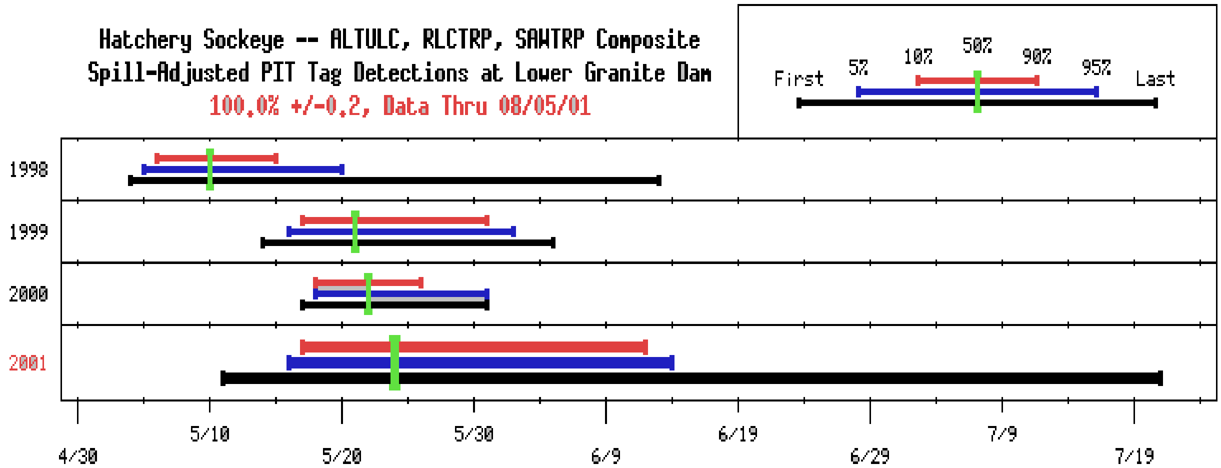


Table B11: Historical PIT-tagged Run-at-Large of Wild Yearling Chinook Salmon outmigration timing characteristics.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1993	04/14	04/25	04/27	05/16	06/03	06/17	08/10	38	3939
1994	04/02	04/21	04/22	05/08	06/06	07/07	09/11	46	6889
1995	04/03	04/14	04/17	05/10	06/21	07/04	09/22	66	9437
1996	03/29	04/13	04/15	04/27	06/03	06/12	08/16	50	5418
1997	03/31	04/11	04/13	04/28	06/06	06/16	09/22	55	2497
1998	03/27	04/06	04/11	05/01	05/27	06/27	09/29	47	13425
1999	03/26	04/13	04/19	05/02	06/08	06/19	08/23	51	17945
2000	04/02	04/13	04/14	05/01	06/01	06/19	09/14	49	14541
2001	03/30	04/18	04/22	05/02	05/27	06/07	08/25	36	18076

Figure B12: Historical Composite of Alturas Lake Creek, Redfish Lake Creek Trap, Sawtooth Trap PIT-tagged hatchery-reared sockeye salmon outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B12: Historical Composite of Alturas Lake Creek, Redfish Lake Creek Trap, Sawtooth Trap PIT-tagged hatchery-reared sockeye salmon outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1998	05/04	05/05	05/06	05/10	05/15	05/20	06/13	10	4176	1333	2555.2	61.2
1999	05/14	05/16	05/17	05/21	05/31	06/02	06/05	15	981	72	180.9	18.4
2000	05/17	05/18	05/18	05/22	05/26	05/31	05/31	9	328	22	42.2	12.9
2001	5/11	05/16	05/17	05/24	06/12	06/14	07/21	27	1650	437	437.0	26.5

Figure B13: Historical Wild PIT-tagged Subyearling Fall Chinook Salmon (SNAKER) out migration distribution at Lower Granite Dam.

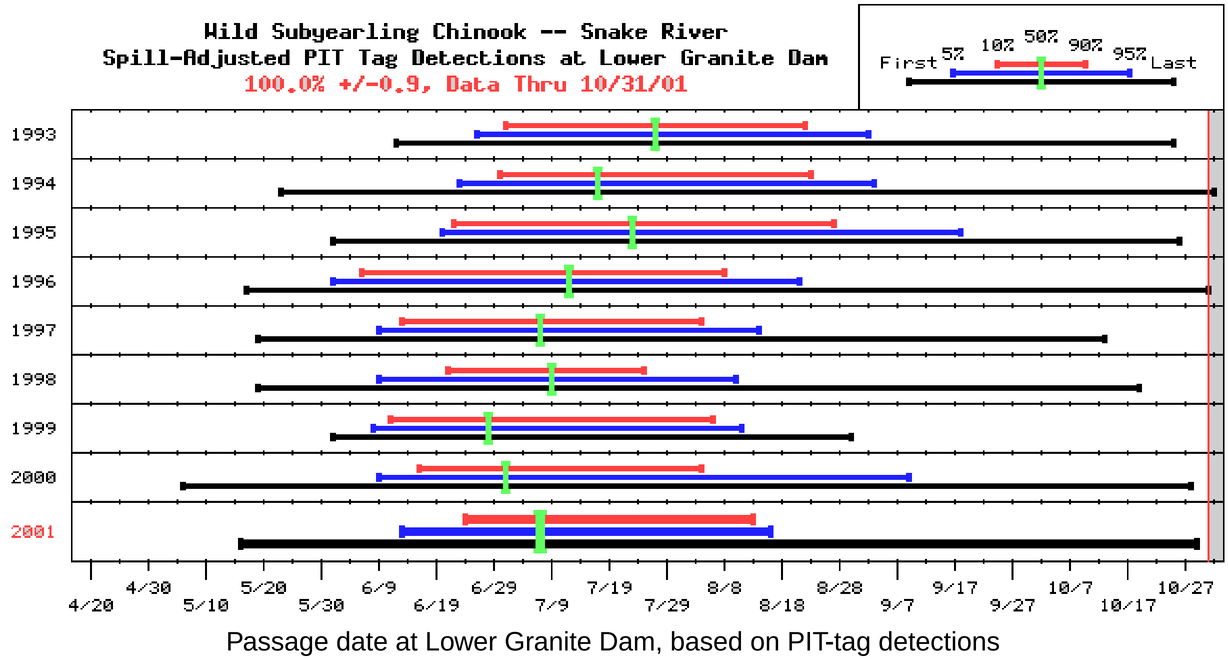


Table B13: Historical Wild PIT-tagged Subyearling Chinook Salmon (SNAKER) outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	06/12	06/26	07/01	07/27	08/22	09/02	10/25	53	1099	172	172.1	15.7
1994	05/23	06/23	06/30	07/17	08/23	09/03	11/01	55	2342	93	199.1	8.5
1995	06/01	06/20	06/22	07/23	08/27	09/18	10/26	67	1374	440	454.0	33.0
1996	05/17	06/01	06/06	07/12	08/08	08/21	10/31	64	463	146	186.1	40.2
1997	05/19	06/09	06/13	07/07	08/04	08/14	10/13	53	641	124	164.3	25.6
1998	05/19	06/09	06/21	07/09	07/25	08/10	10/19	35	2054	549	676.1	32.9
1999	06/01	06/08	06/11	06/28	08/06	08/11	08/30	57	1758	559	802.5	45.6
2000	05/06	06/09	06/16	07/01	08/04	09/09	10/28	50	1209	327	376.0	31.1
2001	05/16	06/13	06/24	07/07	08/13	08/16	10/29	51	1378	195	196.8	14.3

Figure B14: Historical PIT-tagged Run-at-Large of Wild Steelhead Trout Outmigration Distribution at Lower Granite Dam.

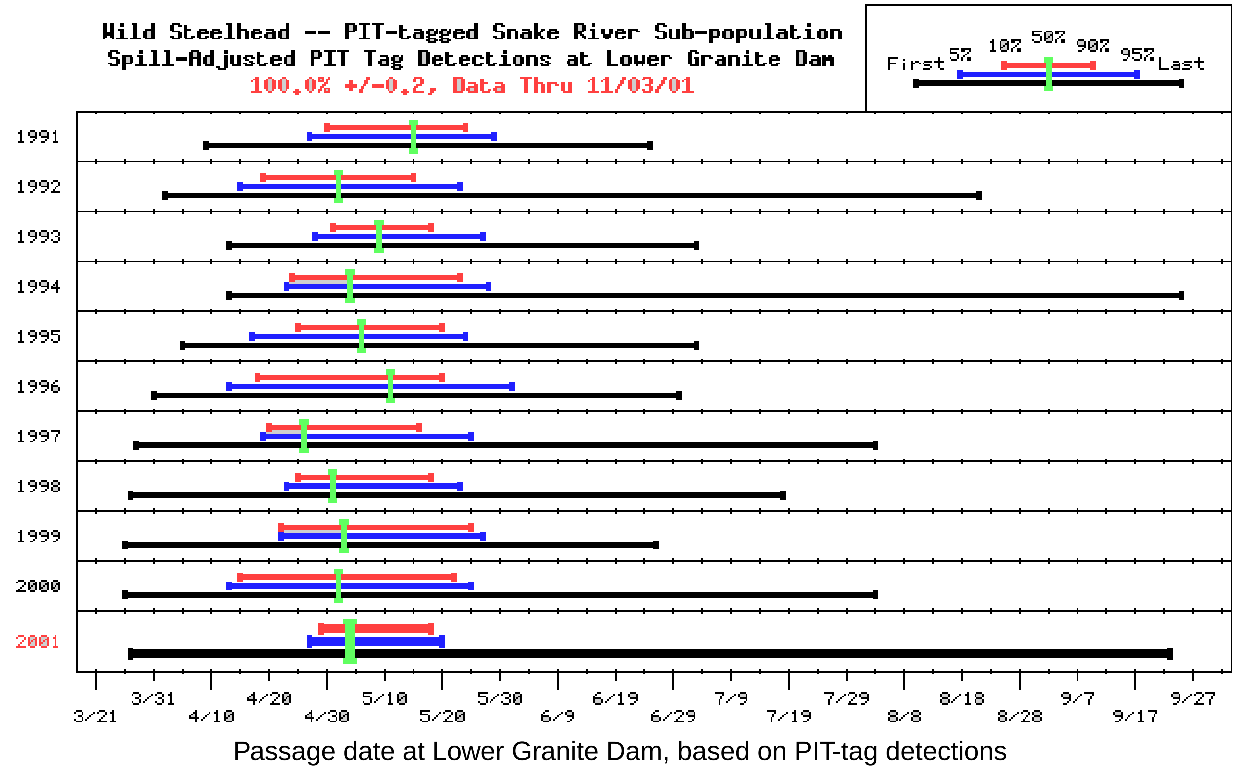


Table B14: Historical PIT-tagged Run-at-Large of Wild Steelhead Trout Outmigration timing characteristics at Lower Granite Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1991	04/09	04/27	04/30	05/15	05/24	05/29	06/25	25	2914
1992	04/02	04/15	04/19	05/02	05/15	05/23	08/21	27	3638
1993	04/13	04/28	05/01	05/09	05/18	05/27	07/03	18	4757
1994	04/13	04/23	04/24	05/04	05/23	05/28	09/25	30	5346
1995	04/05	04/17	04/25	05/06	05/20	05/24	07/03	26	4458
1996	03/31	04/13	04/18	05/11	05/20	06/01	06/30	33	3966
1997	03/28	04/19	04/20	04/26	05/16	05/25	08/03	27	4459
1998	03/27	04/23	04/25	05/01	05/18	05/23	07/18	24	8522
1999	03/26	04/22	04/22	05/03	05/25	05/27	06/26	34	6988
2000	03/26	04/13	04/15	05/02	05/22	05/25	08/03	38	13604
2001	03/27	04/27	04/29	05/04	05/18	05/20	09/23	20	13570

Figure B15: Historical PIT-tagged Run-at-Large of Wild Snake River Subyearling Fall Chinook Salmon Outmigration Distribution at McNary Dam.

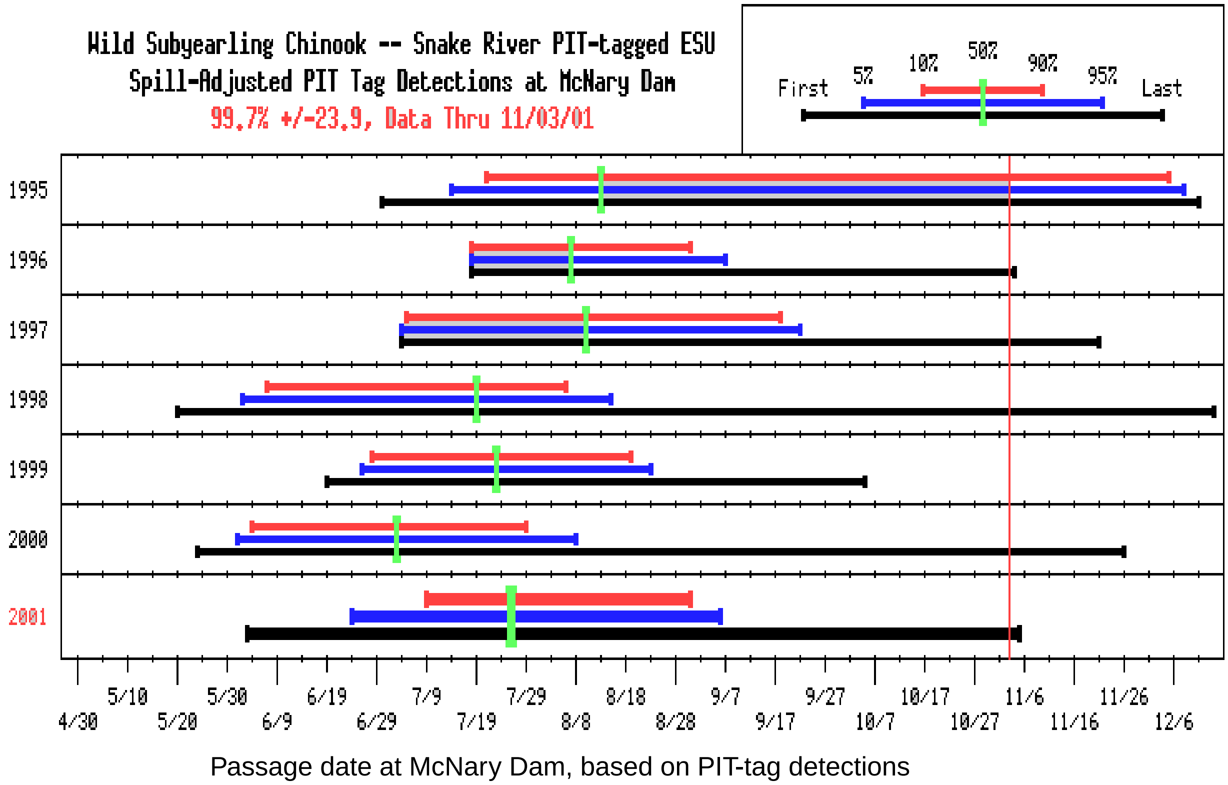


Table B15: Historical outmigration timing characteristics of wild PIT-tagged Snake River Subyearling Fall Chinook Salmon detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1995	06/30	07/14	07/21	08/13	12/05	12/08	12/11	138	183
1996	07/18	07/18	07/18	08/07	08/31	09/07	11/04	45	28
1997	07/04	07/04	07/05	08/10	09/18	09/22	11/21	76	24
1998	05/20	06/02	06/07	07/19	08/06	08/15	12/14	61	439
1999	06/19	06/26	06/28	07/23	08/19	08/23	10/05	53	197
2000	05/24	06/01	06/04	07/03	07/29	08/08	11/26	56	274
2001	06/03	06/24	07/09	07/26	08/31	09/06	11/05	54	54

Figure B16: Historical PIT-tagged Run-at-Large of Wild Upper Columbia River Subyearling Fall Chinook Salmon Outmigration Distribution at McNary Dam.

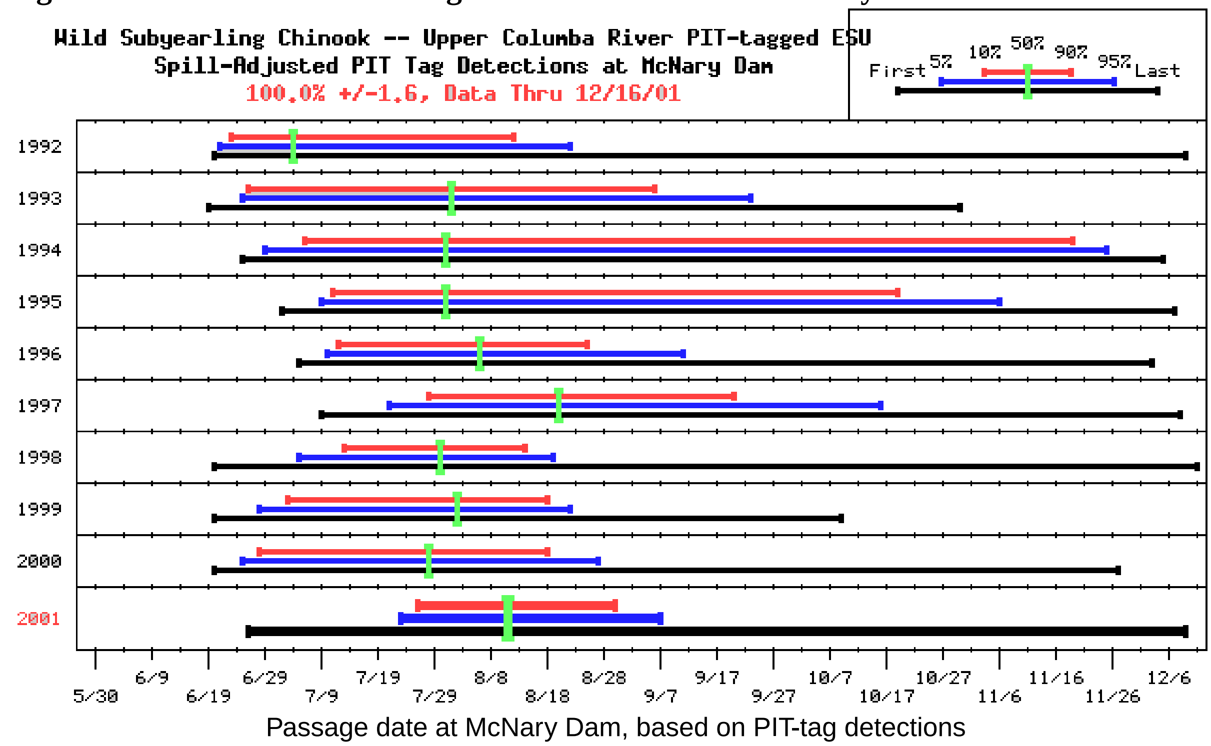
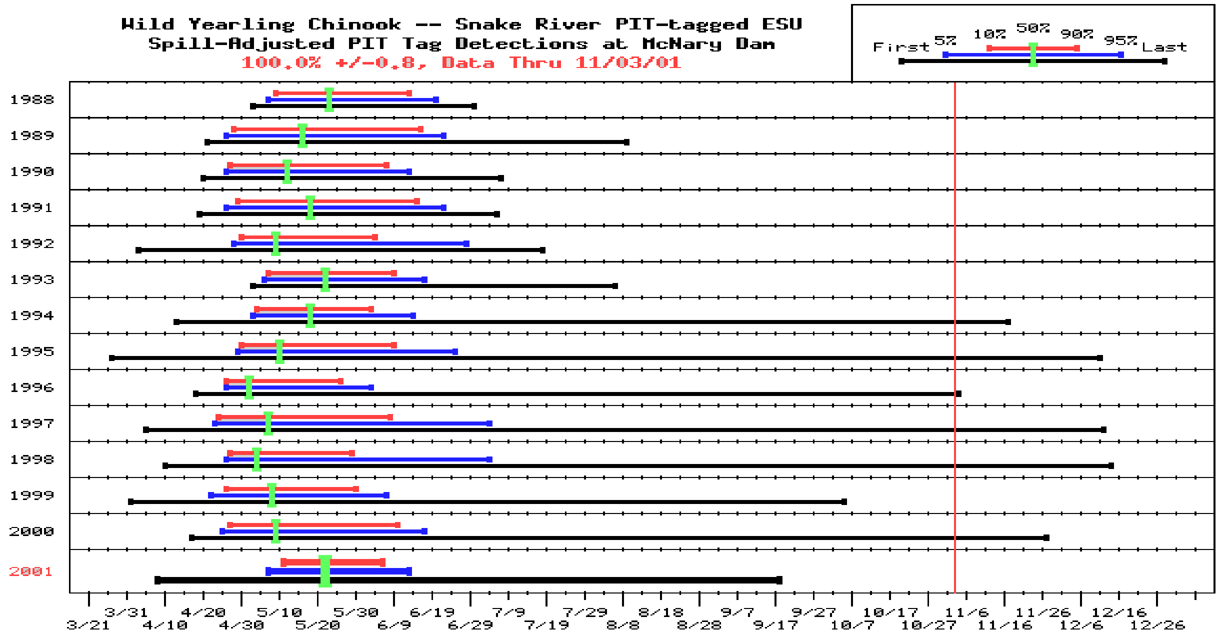


Table B16: Historical outmigration timing characteristics of wild PIT-tagged Columbia River Subyearling Fall Chinook Salmon detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1992	06/20	06/21	06/23	07/04	08/12	08/22	12/09	51	678
1993	06/19	06/25	06/26	08/01	09/06	09/23	10/30	73	585
1994	06/25	06/29	07/06	07/31	11/19	11/25	12/05	137	559
1995	07/02	07/09	07/11	07/31	10/19	11/06	12/07	101	1029
1996	07/05	07/10	07/12	08/06	08/25	09/11	12/03	45	1375
1997	07/09	07/21	07/28	08/20	09/20	10/16	12/08	55	2342
1998	06/20	07/05	07/13	07/30	08/14	08/19	12/11	33	2524
1999	06/20	06/28	07/03	08/02	08/18	08/22	10/09	47	2544
2000	06/20	06/25	06/28	07/28	08/18	08/27	11/27	52	3279
2001	06/26	07/23	07/26	08/11	08/30	09/07	12/09	36	1210

Figure B17: Historical PIT-tagged Run-at-Large of Wild Snake River Yearling Chinook Salmon Outmigration Distribution at McNary Dam.



Passage date at McNary Dam, based on PIT-tag detections

Table B17: Historical outmigration timing characteristics of wild PIT-tagged Snake River Yearling Chinook Salmon detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1988	05/03	05/07	05/09	05/23	06/13	06/20	06/30	36	58
1989	04/21	04/26	04/28	05/16	06/16	06/22	08/09	50	281
1990	04/20	04/26	04/27	05/12	06/07	06/13	07/07	42	213
1991	04/19	04/26	04/29	05/18	06/15	06/22	07/06	48	204
1992	04/03	04/28	04/30	05/09	06/04	06/28	07/18	36	307
1993	05/03	05/06	05/07	05/22	06/09	06/17	08/06	34	1410
1994	04/13	05/03	05/04	05/18	06/03	06/14	11/17	31	6154
1995	03/27	04/29	04/30	05/10	06/09	06/25	12/11	41	20689
1996	04/18	04/26	04/26	05/02	05/26	06/03	11/04	31	4524
1997	04/05	04/23	04/24	05/07	06/08	07/04	12/12	46	676
1998	04/10	04/26	04/27	05/04	05/29	07/04	12/14	33	11126
1999	04/01	04/22	04/26	05/08	05/30	06/07	10/05	35	22487
2000	04/17	04/25	04/27	05/09	06/10	06/17	11/27	45	24905
2001	04/08	05/07	05/11	05/22	06/06	06/13	09/18	27	8782

Figure B18: Historical PIT-tagged Run-at-Large of Wild Snake River Sockeye Salmon Out-migration Distribution at McNary Dam.

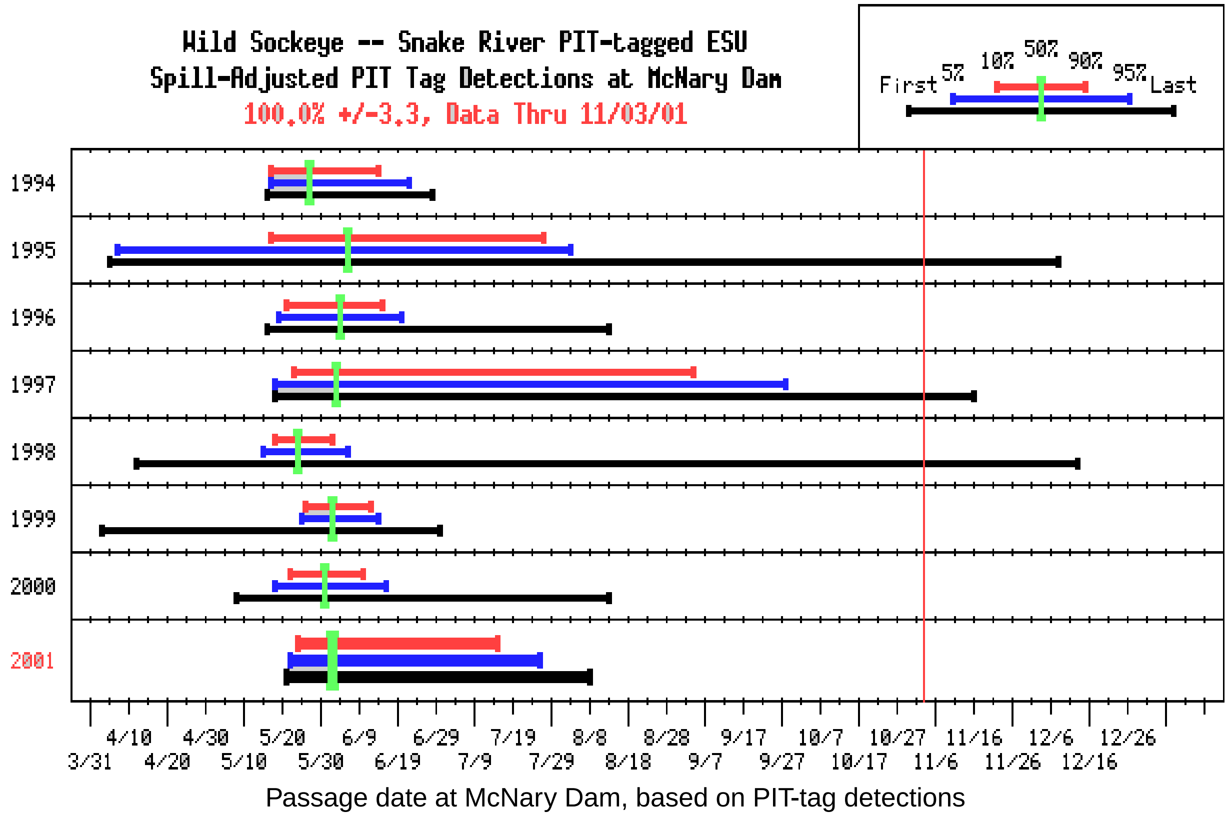


Table B18: Historical outmigration timing characteristics of wild PIT-tagged Snake River Sockeye Salmon detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1994	05/16	05/17	05/17	05/27	06/14	06/22	06/28	29	59
1995	04/05	04/07	05/17	06/06	07/27	08/03	12/08	72	37
1996	05/16	05/19	05/21	06/04	06/15	06/20	08/13	26	119
1997	05/18	05/18	05/23	06/03	09/04	09/28	11/16	105	38
1998	04/12	05/15	05/18	05/24	06/02	06/06	12/13	16	471
1999	04/03	05/25	05/26	06/02	06/12	06/14	06/30	18	347
2000	05/08	05/18	05/22	05/31	06/10	06/16	08/13	20	600
2001	05/21	05/22	05/24	06/02	07/15	07/26	08/08	53	38

Figure B19: Historical PIT-tagged Run-at-Large of Wild Snake River Steelhead Trout Out-migration Distribution at McNary Dam.

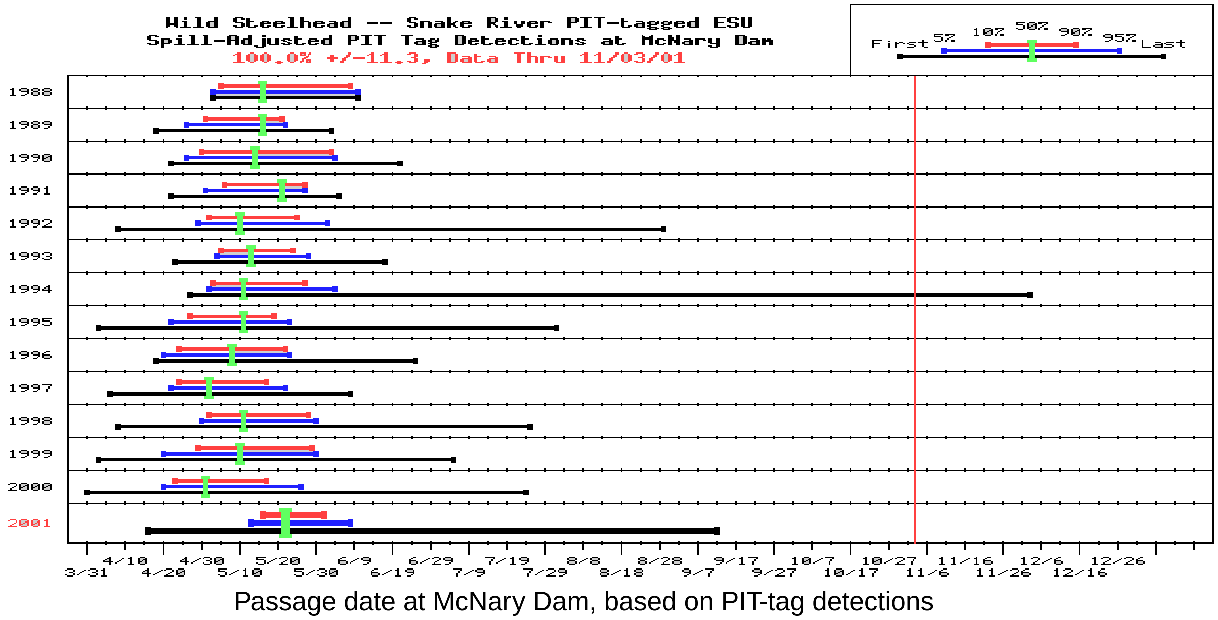


Table B19: Historical outmigration timing characteristics of wild PIT-tagged Snake River Steelhead Trout smolts detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1988	05/03	05/03	05/05	05/16	06/08	06/10	06/10	35	18
1989	04/18	04/26	05/01	05/16	05/21	05/22	06/03	21	166
1990	04/22	04/26	04/30	05/14	06/03	06/04	06/21	35	119
1991	04/22	05/01	05/06	05/21	05/27	05/27	06/05	22	160
1992	04/08	04/29	05/02	05/10	05/25	06/02	08/29	24	479
1993	04/23	05/04	05/05	05/13	05/24	05/28	06/17	20	910
1994	04/27	05/02	05/03	05/11	05/27	06/04	12/03	25	1945
1995	04/03	04/22	04/27	05/11	05/19	05/23	08/01	23	1416
1996	04/18	04/20	04/24	05/08	05/22	05/23	06/25	29	1117
1997	04/06	04/22	04/24	05/02	05/17	05/22	06/08	24	1156
1998	04/08	04/30	05/02	05/11	05/28	05/30	07/25	27	2674
1999	04/03	04/20	04/29	05/10	05/29	05/30	07/05	31	4955
2000	03/31	04/20	04/23	05/01	05/17	05/26	07/24	25	12093
2001	04/16	05/13	05/16	05/22	06/01	06/08	09/12	17	2641

Figure B20: Historical PIT-tagged Run-at-Large of Wild Upper Columbia River Steelhead Trout Outmigration Distribution at McNary Dam.

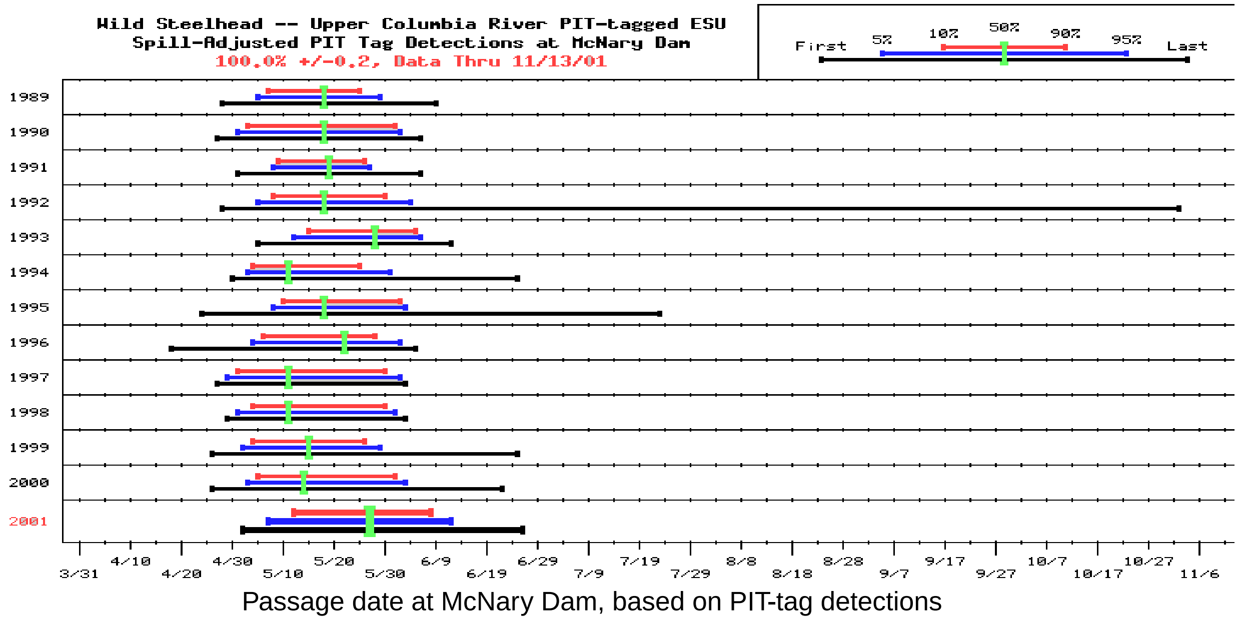


Table B20: Historical outmigration timing characteristics of wild PIT-tagged Upper Columbia River Steelhead Trout smolts detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1989	04/28	05/05	05/07	05/18	05/25	05/29	06/09	19	262
1990	04/27	05/01	05/03	05/18	06/01	06/02	06/06	30	279
1991	05/01	05/08	05/09	05/19	05/26	05/27	06/06	18	352
1992	04/28	05/05	05/08	05/18	05/30	06/04	11/02	23	397
1993	05/05	05/12	05/15	05/28	06/05	06/06	06/12	22	144
1994	04/30	05/03	05/04	05/11	05/25	05/31	06/25	22	367
1995	04/24	05/08	05/10	05/18	06/02	06/03	07/23	24	251
1996	04/18	05/04	05/06	05/22	05/28	06/02	06/05	23	261
1997	04/27	04/29	05/01	05/11	05/30	06/02	06/03	30	193
1998	04/29	05/01	05/04	05/11	05/30	06/01	06/03	27	206
1999	04/26	05/02	05/04	05/15	05/26	05/29	06/25	23	9615
2000	04/26	05/03	05/05	05/14	06/01	06/03	06/22	28	5240
2001	05/02	05/07	05/12	05/27	06/08	06/12	06/26	28	191

Figure B21: Historical PIT-tagged Run-at-Large of Wild Snake and Upper Columbia River Steelhead Trout Outmigration Distribution at McNary Dam.

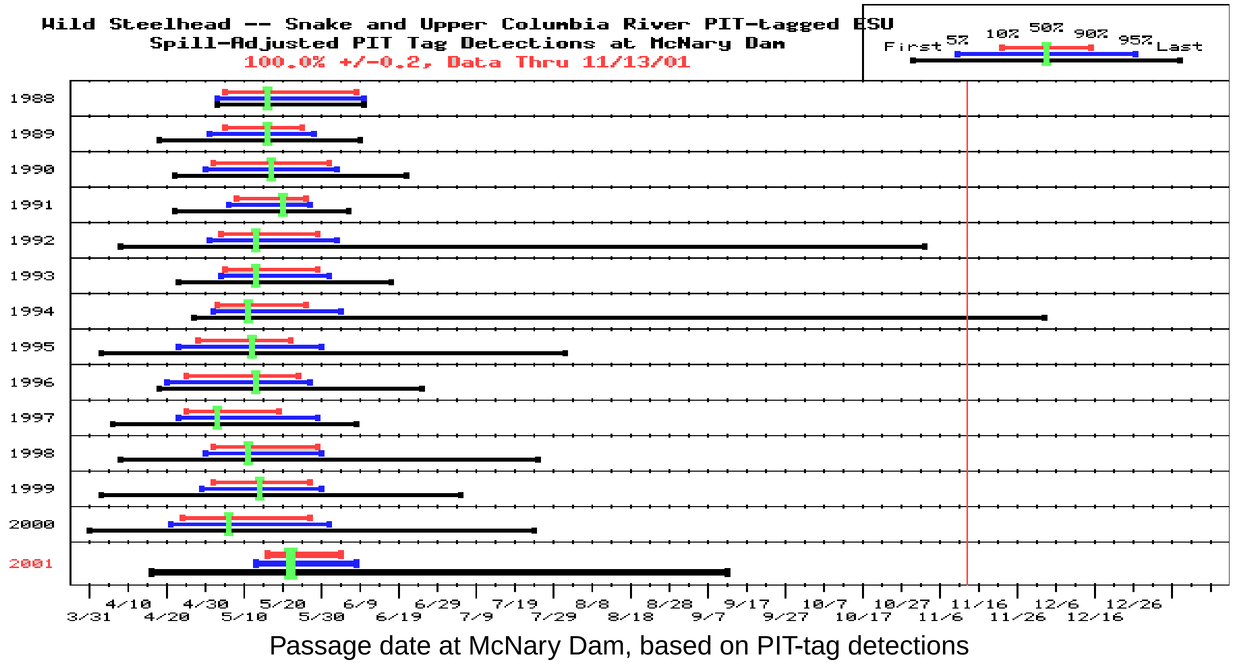


Table B21: Historical outmigration timing characteristics of wild PIT-tagged Snake and Upper Columbia River Steelhead Trout smolts detected at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1988	05/03	05/03	05/05	05/16	06/08	06/10	06/10	35	18
1989	04/18	05/01	05/05	05/16	05/25	05/28	06/09	21	428
1990	04/22	04/30	05/02	05/17	06/01	06/03	06/21	31	399
1991	04/22	05/06	05/08	05/20	05/26	05/27	06/06	19	513
1992	04/08	05/01	05/04	05/13	05/29	06/03	11/02	26	877
1993	04/23	05/04	05/05	05/13	05/29	06/01	06/17	25	1055
1994	04/27	05/02	05/03	05/11	05/26	06/04	12/03	24	2313
1995	04/03	04/23	04/28	05/12	05/22	05/30	08/01	25	1668
1996	04/18	04/20	04/25	05/13	05/24	05/27	06/25	30	1378
1997	04/06	04/23	04/25	05/03	05/19	05/29	06/08	25	1349
1998	04/08	04/30	05/02	05/11	05/29	05/30	07/25	28	2880
1999	04/03	04/29	05/02	05/14	05/27	05/30	07/05	26	14570
2000	03/31	04/21	04/24	05/06	05/27	06/01	07/24	34	17333
2001	04/16	05/13	05/16	05/22	06/04	06/08	09/12	20	2833

Figure B22: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Subyearling Chinook Salmon Outmigration Distribution at Rock Island Dam.

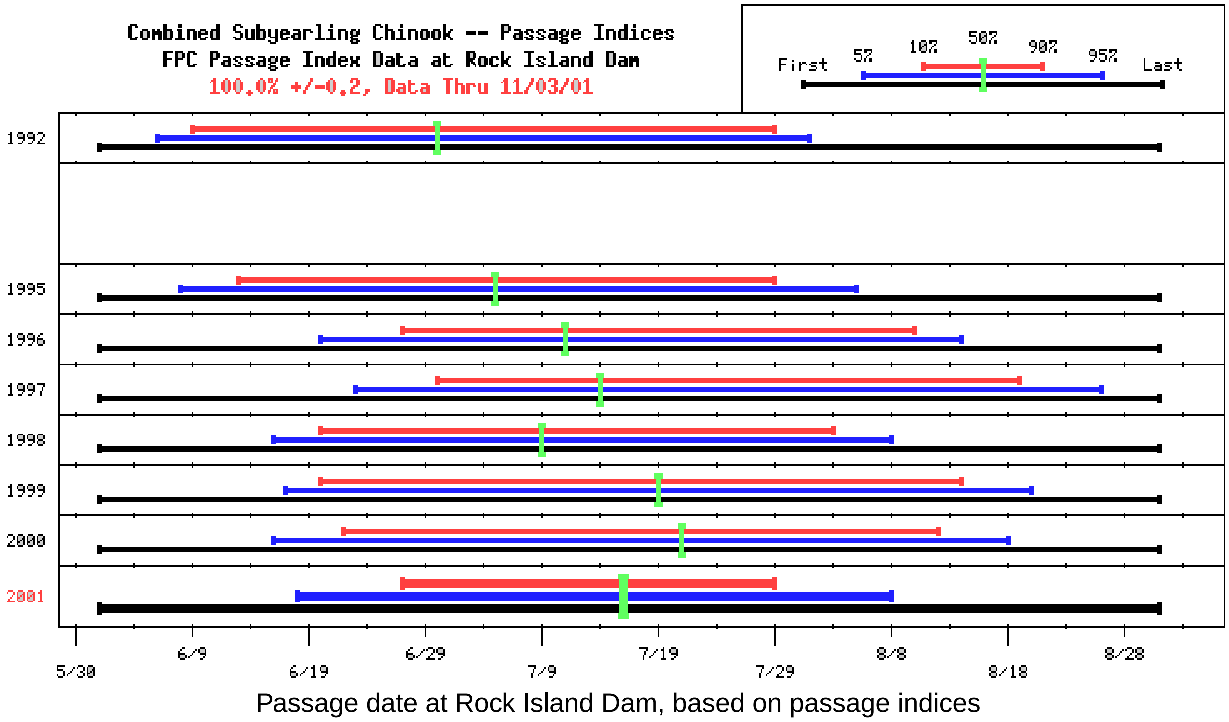


Table B22: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration timing characteristics at Rock Island Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total RIS Passage
	First	5%	10%	50%	90%	95%	Last		
1992	06/01	06/06	06/09	06/30	07/29	08/01	08/31	51	10339
1995	06/01	06/08	06/13	07/05	07/29	08/05	08/31	47	14149
1996	06/01	06/20	06/27	07/11	08/10	08/14	08/31	45	15294
1997	06/01	06/23	06/30	07/14	08/19	08/26	08/31	51	19246
1998	06/01	06/16	06/20	07/09	08/03	08/08	08/31	45	17218
1999	06/01	06/17	06/20	07/19	08/14	08/20	08/31	56	28340
2000	06/01	06/16	06/22	07/21	08/12	08/18	08/31	52	13693
2001	06/01	06/18	06/27	07/16	07/29	08/08	08/31	33	22651

Figure B23: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Yearling Chinook Salmon Outmigration Distribution at Rock Island Dam.

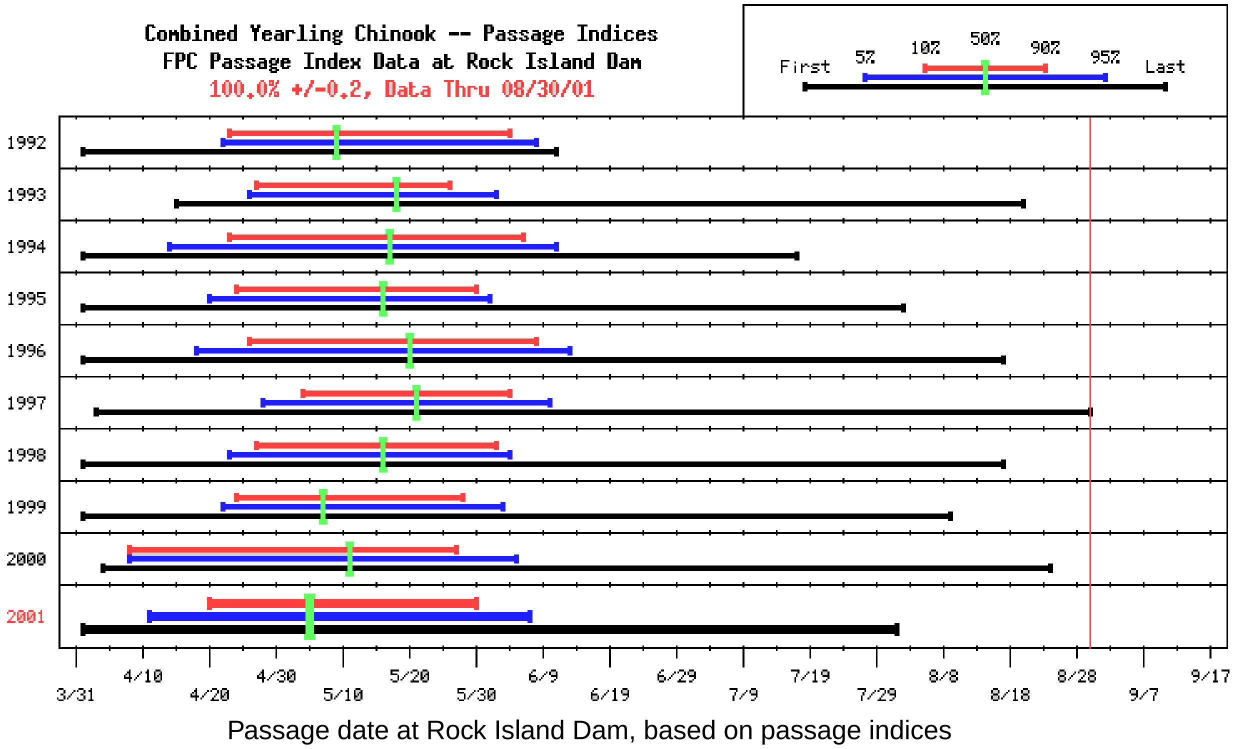


Table B23: Historical Combined Wild and Hatchery Yearling Chinook Salmon outmigration timing characteristics at Rock Island Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total RIS Passage
	First	5%	10%	50%	90%	95%	Last		
1992	04/01	04/22	04/23	05/09	06/04	06/08	06/11	43	16100
1993	04/15	04/26	04/27	05/18	05/26	06/02	08/20	30	13514
1994	04/01	04/14	04/23	05/17	06/06	06/11	07/17	45	12324
1995	04/01	04/20	04/24	05/16	05/30	06/01	08/02	37	30753
1996	04/01	04/18	04/26	05/20	06/08	06/13	08/17	44	42478
1997	04/03	04/28	05/04	05/21	06/04	06/10	08/30	32	53754
1998	04/01	04/23	04/27	05/16	06/02	06/04	08/17	37	24859
1999	04/01	04/22	04/24	05/07	05/28	06/03	08/09	35	40320
2000	04/04	04/08	04/08	05/11	05/27	06/05	08/24	50	32334
2001	04/01	04/11	04/20	05/05	05/30	06/07	08/01	41	6635

Figure B24: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Coho Salmon Outmigration Distribution at Rock Island Dam.

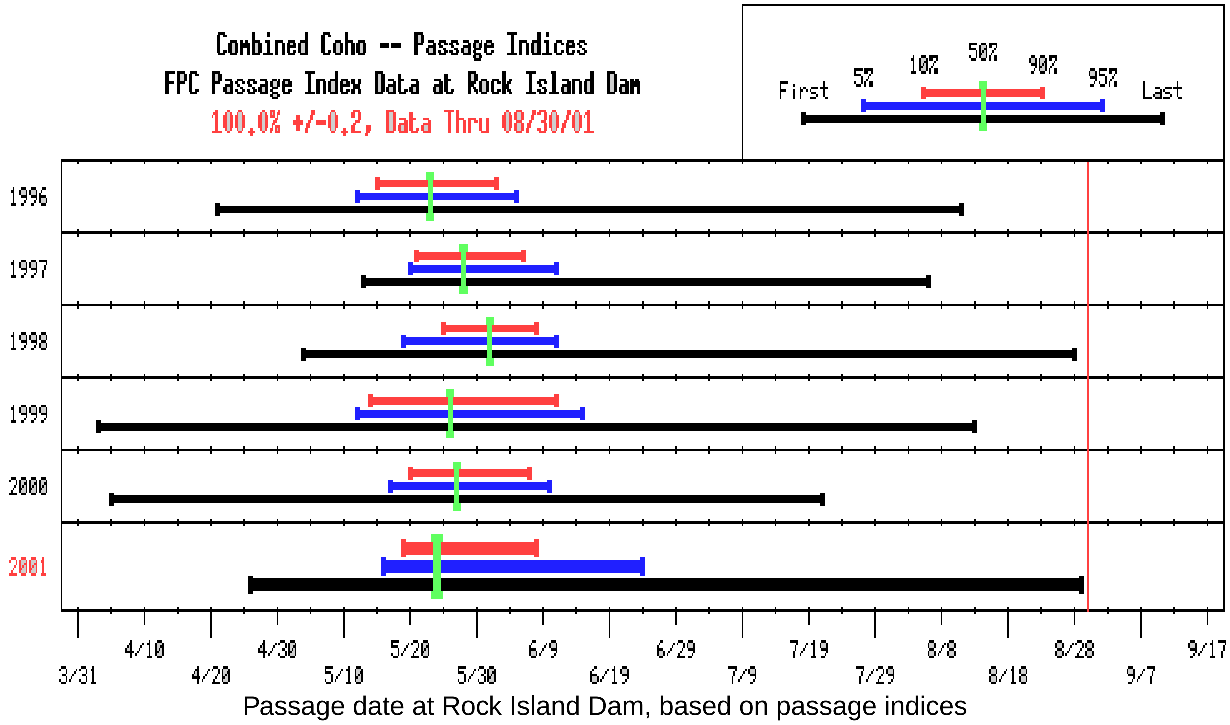


Table B24: Historical Combined Wild and Hatchery Coho Salmon outmigration timing characteristics at Rock Island Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total RIS Passage
	First	5%	10%	50%	90%	95%	Last		
1996	04/21	05/12	05/15	05/23	06/02	06/05	08/11	19	26521
1997	05/13	05/20	05/21	05/28	06/06	06/11	08/06	17	4301
1998	05/04	05/19	05/25	06/01	06/08	06/11	08/28	15	41837
1999	04/03	05/12	05/14	05/26	06/11	06/15	08/13	29	46173
2000	04/05	05/17	05/20	05/27	06/07	06/10	07/21	19	49552
2001	04/26	05/16	05/19	05/24	06/08	06/24	08/30	21	45437

Figure B25: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Sockeye Salmon Outmigration Distribution at Rock Island Dam.

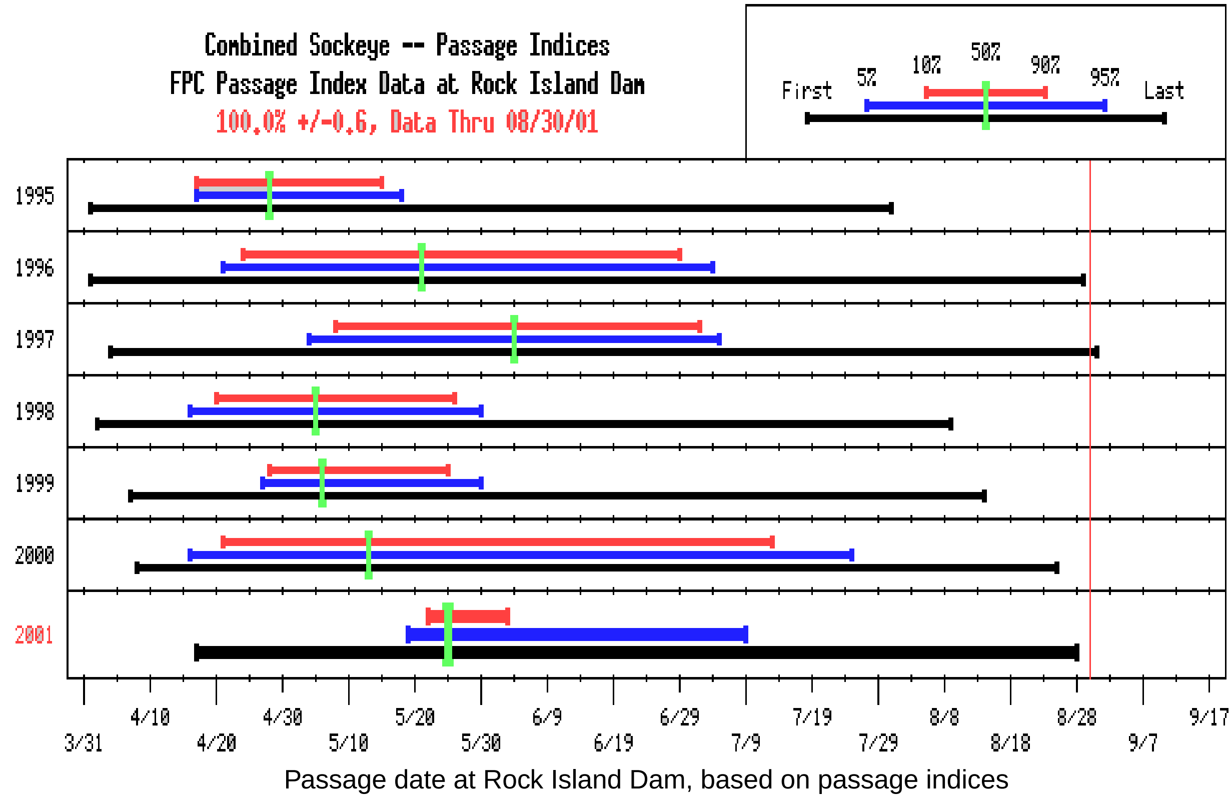


Table B25: Historical Combined Wild and Hatchery Sockeye Salmon outmigration timing characteristics at Rock Island Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total RIS Passage
	First	5%	10%	50%	90%	95%	Last		
1995	04/01	04/17	04/17	04/28	05/15	05/18	07/31	29	27056
1996	04/01	04/21	04/24	05/21	06/29	07/04	08/29	67	9995
1997	04/04	05/04	05/08	06/04	07/02	07/05	08/31	56	13426
1998	04/02	04/16	04/20	05/05	05/26	05/30	08/09	37	16635
1999	04/07	04/27	04/28	05/06	05/25	05/30	08/14	28	23371
2000	04/08	04/16	04/21	05/13	07/13	07/25	08/25	84	2430
2001	04/17	05/19	05/22	05/25	06/04	07/09	08/31	14	3032

Figure B26: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Steelhead Trout Salmon Outmigration Distribution at Rock Island Dam.

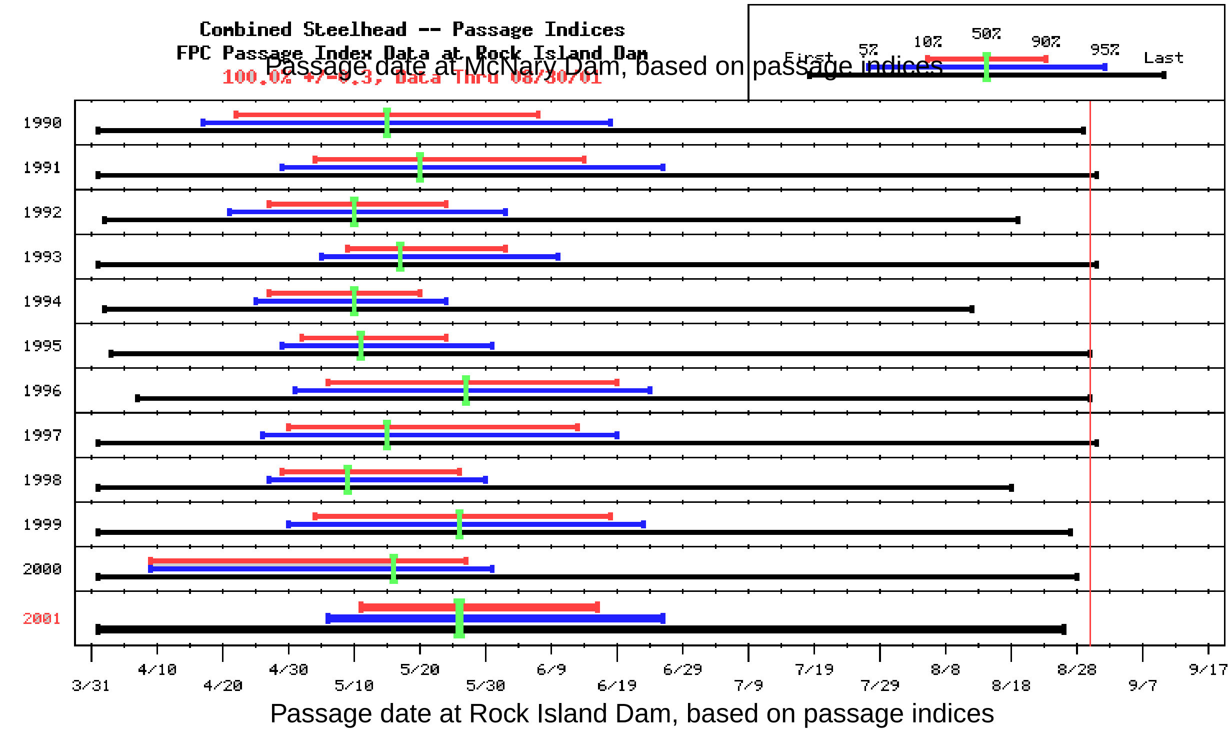


Table B26: Historical Combined Wild and Hatchery Steelhead Trout outmigration timing characteristics at Rock Island Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total RIS Passage
	First	5%	10%	50%	90%	95%	Last		
1990	04/01	04/17	04/22	05/15	06/07	06/18	08/29	47	3739
1991	04/01	04/29	05/04	05/20	06/14	06/26	08/31	42	4953
1992	04/02	04/21	04/27	05/10	05/24	06/02	08/19	28	4906
1993	04/01	05/05	05/09	05/17	06/02	06/10	08/31	25	4032
1994	04/02	04/25	04/27	05/10	05/20	05/24	08/12	24	15323
1995	04/03	04/29	05/02	05/11	05/24	05/31	08/30	23	18084
1996	04/07	05/01	05/06	05/27	06/19	06/24	08/30	45	39650
1997	04/01	04/26	04/30	05/15	06/13	06/19	08/31	45	33979
1998	04/01	04/27	04/29	05/09	05/26	05/30	08/18	28	21390
1999	04/01	04/30	05/04	05/26	06/18	06/23	08/27	46	48192
2000	04/01	04/09	04/09	05/16	05/27	05/31	08/28	49	26297
2001	04/01	05/06	05/11	05/26	06/16	06/26	08/30	37	17914

Figure B27: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Subyearling Fall Chinook Salmon Outmigration Distribution at McNary Dam.

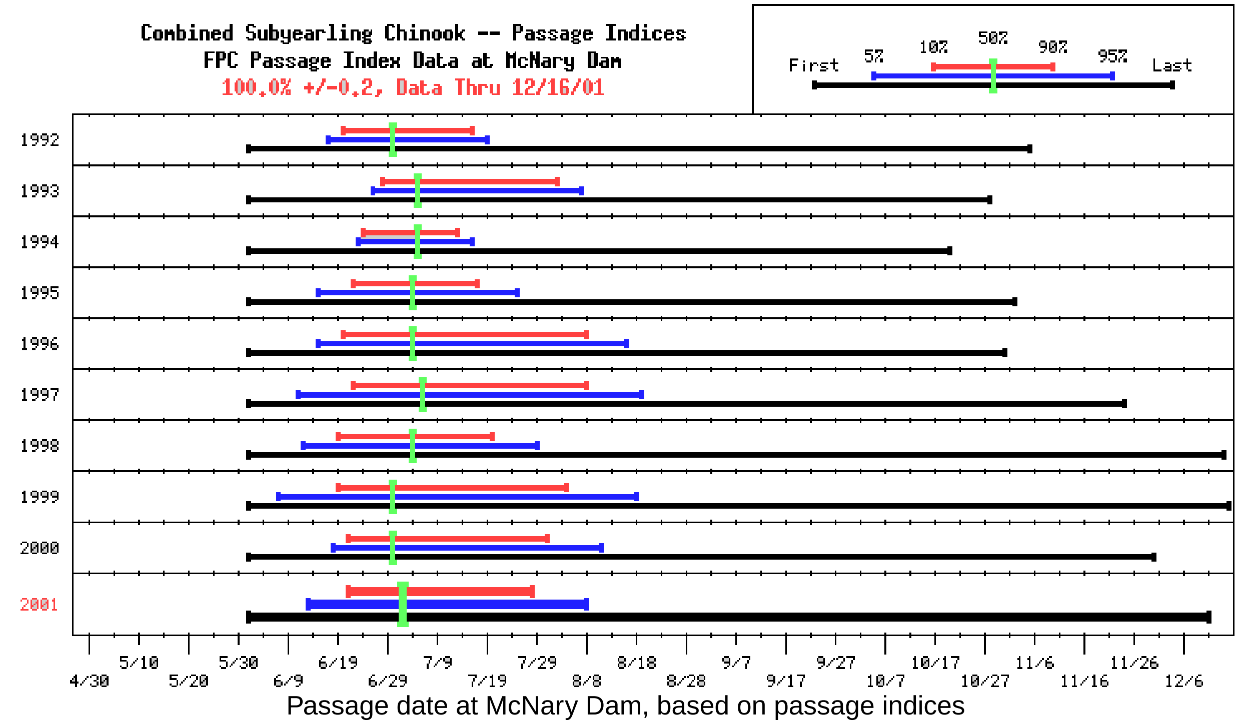


Table B27: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1992	06/01	06/17	06/20	06/30	07/16	07/19	11/05	27	6179484
1993	06/01	06/26	06/28	07/05	08/02	08/07	10/28	36	283813
1994	06/01	06/23	06/24	07/05	07/13	07/16	10/20	20	5053511
1995	06/01	06/15	06/22	07/04	07/17	07/25	11/02	26	8223192
1996	06/01	06/15	06/20	07/04	08/08	08/16	10/31	50	6072944
1997	06/01	06/11	06/22	07/06	08/08	08/19	11/24	48	10383928
1998	06/01	06/12	06/19	07/04	07/20	07/29	12/14	32	11440908
1999	06/01	06/07	06/19	06/30	08/04	08/18	12/15	47	7645173
2000	06/01	06/18	06/21	06/30	07/31	08/11	11/30	41	10661814
2001	06/01	06/13	06/21	07/02	07/28	08/08	12/11	38	10777847

Figure B28: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Yearling Chinook Salmon Outmigration Distribution at McNary Dam.

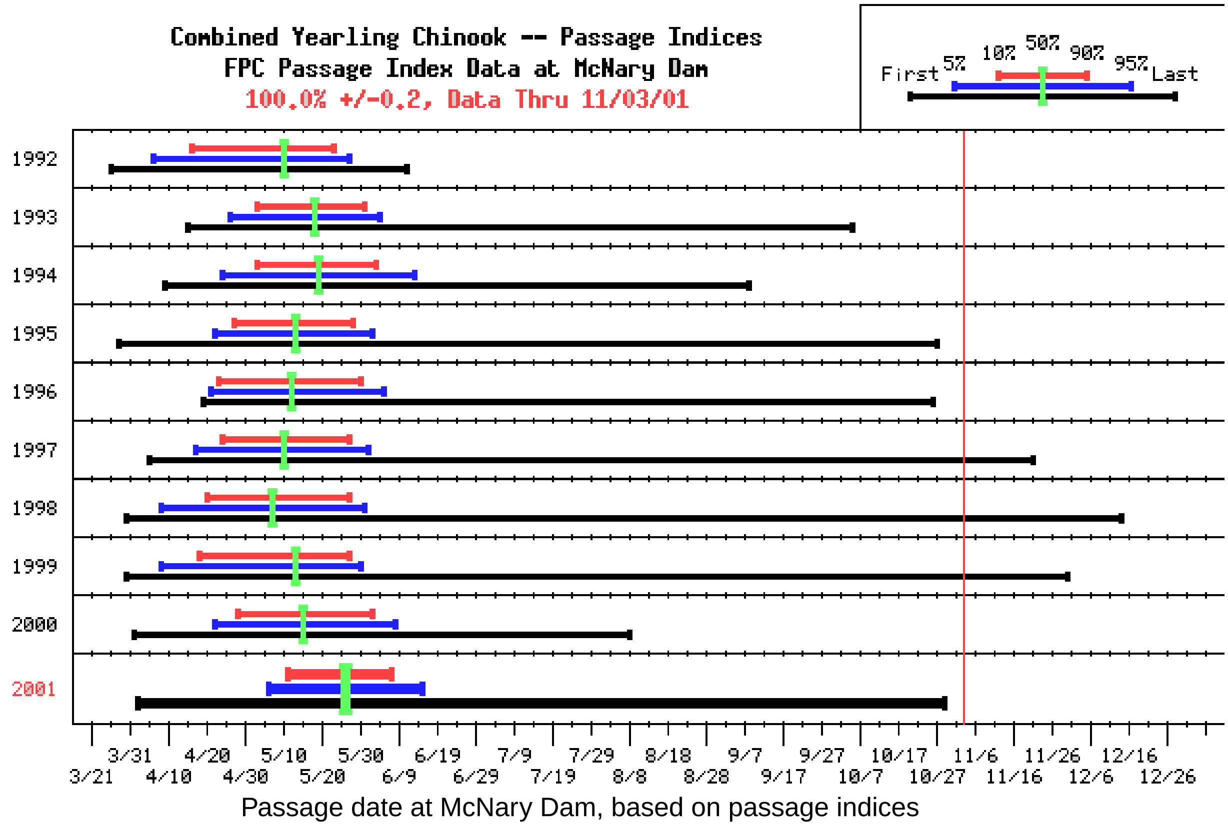


Table B28: Historical Combined Wild and Hatchery Yearling Chinook Salmon outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1992	03/26	04/06	04/16	05/10	05/23	05/27	06/11	38	2514319
1993	04/15	04/26	05/03	05/18	05/31	06/04	10/05	29	1729010
1994	04/09	04/24	05/03	05/19	06/03	06/13	09/08	32	2572338
1995	03/28	04/22	04/27	05/13	05/28	06/02	10/27	32	2879069
1996	04/19	04/21	04/23	05/12	05/30	06/05	10/26	38	1240878
1997	04/05	04/17	04/24	05/10	05/27	06/01	11/21	34	1184530
1998	03/30	04/08	04/20	05/07	05/27	05/31	12/14	38	1727071
1999	03/30	04/08	04/18	05/13	05/27	05/30	11/30	40	3692944
2000	04/01	04/22	04/28	05/15	06/02	06/08	08/08	36	1986380
2001	04/02	05/06	05/11	05/26	06/07	06/15	11/12	28	2299489

Figure B29: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Coho Salmon Outmigration Distribution at McNary Dam.

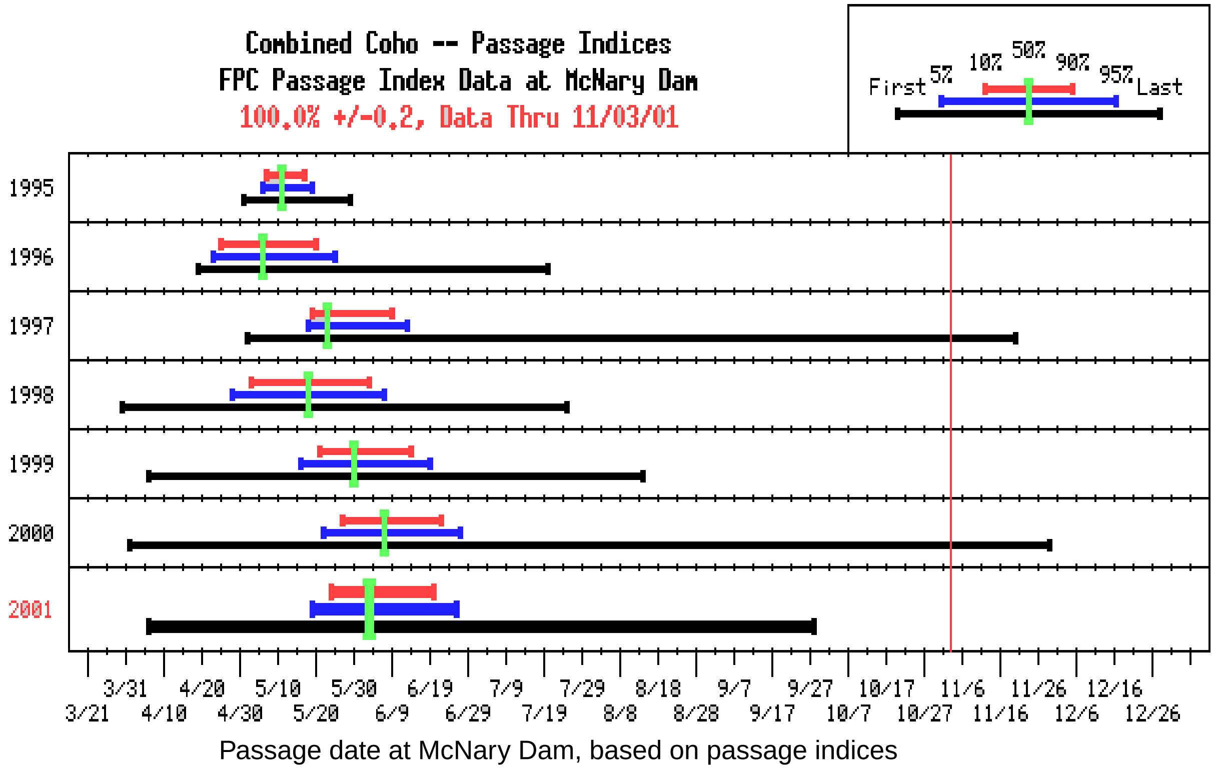


Table B29: Historical Combined Wild and Hatchery Yearling Coho Salmon outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1995	05/01	05/06	05/07	05/11	05/17	05/19	05/29	11	236480
1996	04/19	04/23	04/25	05/06	05/20	05/25	07/20	26	647586
1997	05/02	05/18	05/19	05/23	06/09	06/13	11/20	22	339949
1998	03/30	04/28	05/03	05/18	06/03	06/07	07/25	32	241239
1999	04/06	05/16	05/21	05/30	06/14	06/19	08/14	25	281977
2000	04/01	05/22	05/27	06/07	06/22	06/27	11/29	27	260058
2001	04/06	05/19	05/24	06/03	06/20	06/26	09/28	28	147045

Figure B30: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Sockeye Salmon Outmigration Distribution at McNary Dam.

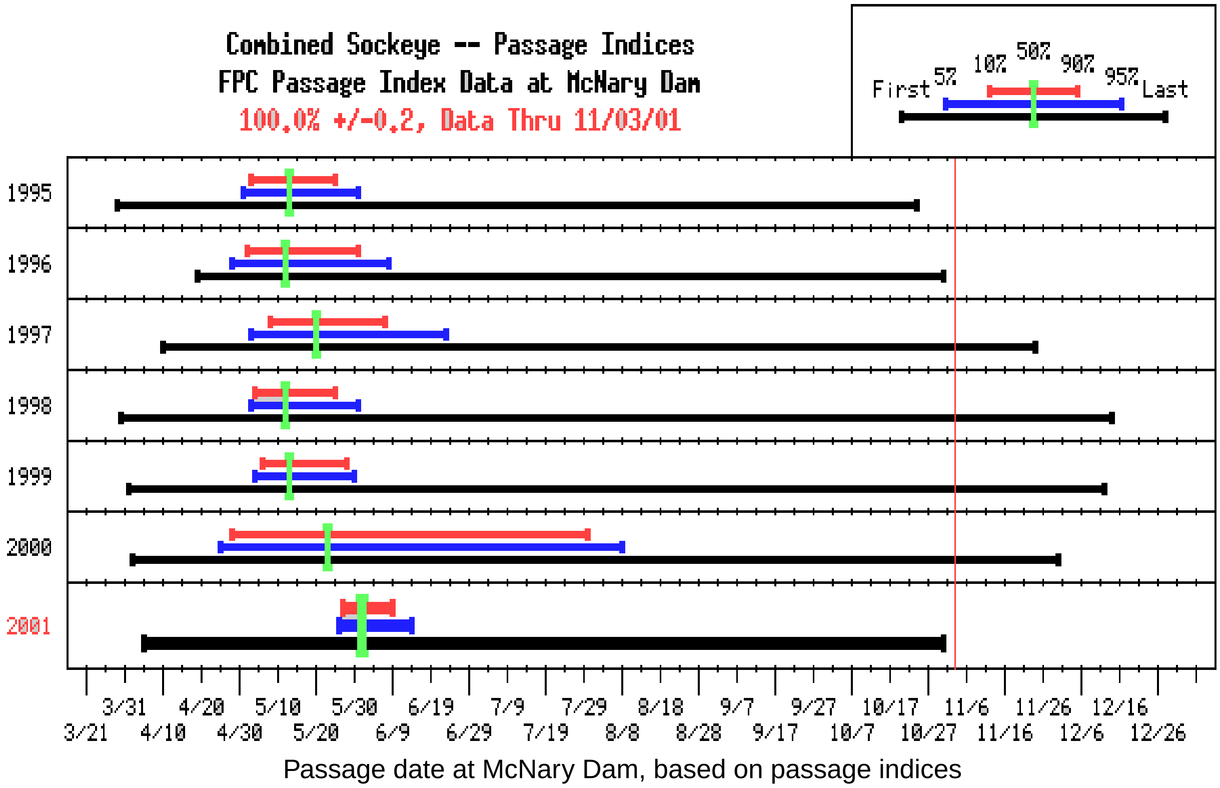


Table B30: Historical Combined Wild and Hatchery Sockeye Salmon outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1995	03/29	05/01	05/03	05/13	05/25	05/31	10/24	23	1003494
1996	04/19	04/28	05/02	05/12	05/31	06/08	10/31	30	155094
1997	04/10	05/03	05/08	05/20	06/07	06/23	11/24	31	221166
1998	03/30	05/03	05/04	05/12	05/25	05/31	12/14	22	966549
1999	04/01	05/04	05/06	05/13	05/28	05/30	12/12	23	1446326
2000	04/02	04/25	04/28	05/23	07/30	08/08	11/30	94	139909
2001	04/05	05/26	05/27	06/01	06/09	06/14	11/11	14	284965

Figure B31: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Steelhead Trout Outmigration Distribution at McNary Dam.

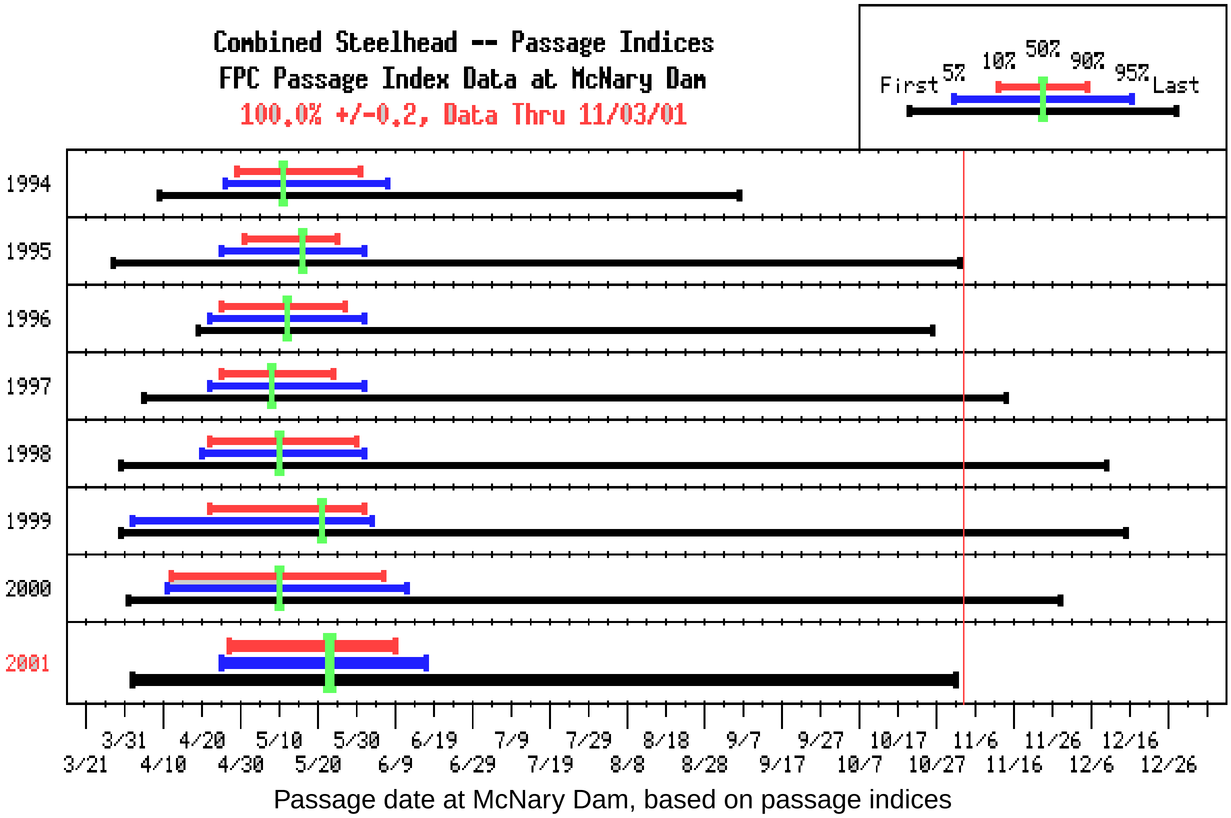


Table B31: Historical Combined Wild and Hatchery Steelhead Trout outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total MCN Passage
	First	5%	10%	50%	90%	95%	Last		
1994	04/09	04/26	04/29	05/11	05/31	06/07	09/06	33	106520
1995	03/28	04/25	05/01	05/16	05/25	06/01	11/02	25	734878
1996	04/19	04/22	04/25	05/12	05/27	06/01	10/26	33	792462
1997	04/05	04/22	04/25	05/08	05/24	06/01	11/14	30	1234024
1998	03/30	04/20	04/22	05/10	05/30	06/01	12/10	39	571119
1999	03/30	04/02	04/22	05/21	06/01	06/03	12/15	41	1004348
2000	04/01	04/11	04/12	05/10	06/06	06/12	11/28	56	617482
2001	04/02	04/25	04/27	05/23	06/09	06/17	11/13	44	562611

Figure B32: Historical Passage-Indexed Run-at-Large of Wild and Hatchery Subyearling Fall Chinook Salmon Outmigration Distribution at John Day Dam.

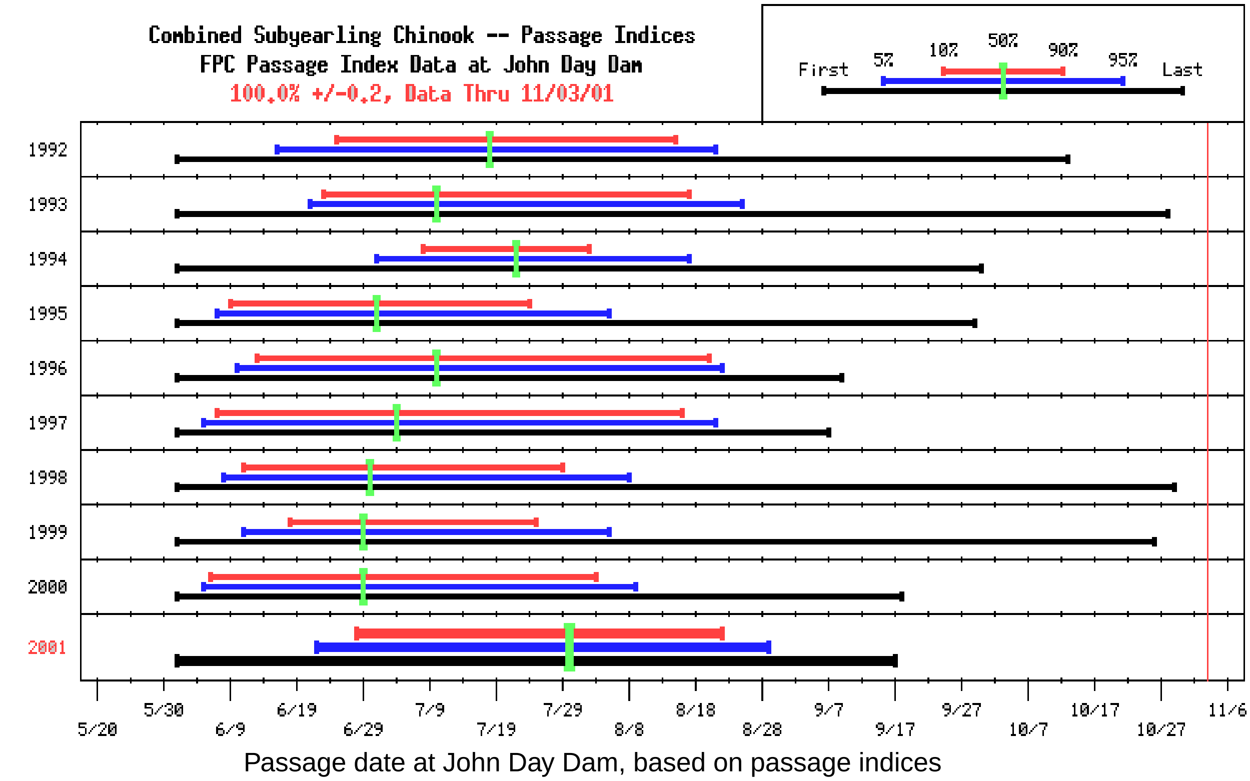


Table B32: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration timing characteristics at John Day Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total JDA Passage
	First	5%	10%	50%	90%	95%	Last		
1992	06/01	06/16	06/25	07/18	08/15	08/21	10/13	52	549586
1993	06/01	06/21	06/23	07/10	08/17	08/25	10/28	56	1252777
1994	06/01	07/01	07/08	07/22	08/02	08/17	09/30	26	1207389
1995	06/01	06/07	06/09	07/01	07/24	08/05	09/29	46	1240275
1996	06/01	06/10	06/13	07/10	08/20	08/22	09/09	69	737912
1997	06/01	06/05	06/07	07/04	08/16	08/21	09/07	71	444651
1998	06/01	06/08	06/11	06/30	07/29	08/08	10/29	49	2155342
1999	06/01	06/11	06/18	06/29	07/25	08/05	10/26	38	3962629
2000	06/01	06/05	06/06	06/29	08/03	08/09	09/18	59	1664301
2001	06/01	06/22	06/28	07/30	08/22	08/29	09/17	56	2849766

Appendix C

Daily Expansion Factors for Spill-Adjusted PIT-Tagged Stocks Forecasted by Project RealTime in Migration Year 2001, including Fall Subyearling Chinook Salmon and Steelhead Trout at Lower Granite Dam and salmonids tracked to McNary Dam

Table C.1: Daily expansion factors used by Program RealTime in 2001 to upwardly adjust the number of raw PIT-tag detections for undetectable fish passing through the spillway at Lower Granite Dam, for chinook salmon and steelhead trout. See section 2.3 for formulas for expansion factors. Dates not included had expansion factors equal to 1.0, because there was no spill on those days.

Migration Year 2001 Dates	Expansion Factors for Chinook Salmon	Expansion Factors for Steelhead Trout
8/27	1.89	1.70
8/28	2.06	1.81
8/29	1.22	1.19
8/30	1.01	1.00
9/11	1.06	1.04
10/5	1.10	1.08
11/5	1.03	1.01
11/6	1.07	1.05
11/7	1.06	1.03
11/8	1.12	1.10
11/9	1.11	1.09

Table C.2: Daily expansion factors used by Program RealTime in 2001 to upwardly adjust the number of raw PIT-tag detections for undetectable fish passing through the spillway at McNary Granite Dam, for chinook salmon and steelhead trout. See section 2.3 for formulas for expansion factors. Dates not included had expansion factors equal to 1.0, because there was no spill on those days.

Migration Year 2001 Dates	Expansion Factors
5/25	1.05
5/26	1.06
5/27	1.06
5/28	1.07
5/29	1.06
5/30	1.05
5/31	1.05
6/1	1.05

Migration Year 2001 Dates	Expansion Factors
6/2	1.06
6/3	1.07
6/4	1.06
6/5	1.05
6/6	1.06
6/7	1.06
6/8	1.05

Migration Year 2001 Dates	Expansion Factors
6/9	1.05
6/10	1.07
6/11	1.06
6/12	1.05
6/13	1.06
6/14	1.06
6/15	1.06

Appendix D

Historical MADs for RealTime 2001 Stocks With More Than Two Years' Inclusion in the Project Including Ten Release-Recovery Stocks of Spring/ Summer Yearling Chinook Salmon Tracked and Forecasted to Lower Granite Dam

Table D.1: Historical MADS for all 2001 Realtime Stocks tracked and forecasted more than two years.

Stock Name	Portion of Outmigration	Year							
		1995	1996	1997	1998	1999	2000	**Hist. Avg.**	**2001**
Bear Valley Creek	First Half	5.6	---	---	8.6	1.4	1.4	**4.3**	**7.0**
	Last Half	3.9	---	---	7.7	9.6	3.8	**6.3**	**10.1**
	Entire Run	4.5	---	---	8.0	8.1	3.3	**6.0**	**9.1**
Catherine Creek	First Half	2.7	3.3	7.9	7.6	4.0	0.8	**4.4**	**10.0**
	Last Half	6.6	6.1	7.1	8.8	7.7	7.6	**7.3**	**5.4**
	Entire Run	5.6	5.4	7.4	8.4	6.2	5.2	**6.4**	**6.5**
Herd Creek	First Half	---	---	---	---	5.5	12.0	**8.8**	**7.8**
	Last Half	---	---	---	---	4.7	4.0	**4.4**	**7.6**
	Entire Run	---	---	---	---	5.1	5.8	**5.5**	**7.7**
Imnaha River	First Half	15.5	6.6	6.3	20.6	3.9	3.3	**9.4**	**5.1**
	Last Half	7.7	6.8	2.2	4.5	3.2	2.4	**4.5**	**5.8**
	Entire Run	10.0	6.8	3.2	10.6	3.4	2.6	**6.1**	**5.6**
Johnson Creek	First Half	---	---	---	---	---	1.8	**1.8**	**6.7**
	Last Half	---	---	---	---	---	6.4	**6.4**	**9.6**
	Entire Run	---	---	---	---	---	4.8	**4.8**	**8.7**

Table D.1: Historical MADS for all 2001 Realtime Stocks tracked and forecasted more than two years.

Stock Name	Portion of Outmigration	Year							
		1995	1996	1997	1998	1999	2000	**Hist. Avg.**	**2001**
Lostine River	First Half	3.4	18.7	5.4	---	4.4	0.9	**6.6**	**3.1**
	Last Half	3.6	4.3	3.9	---	8.1	2.8	**4.5**	**3.0**
	Entire Run	3.5	9.5	4.4	---	5.8	2.1	**5.1**	**3.0**
Minam River	First Half	---	2.7	2.0	16.3	2.8	2.8	**5.3**	**2.1**
	Last Half	---	2.9	10.9	3.5	7.8	1.9	**5.4**	**1.3**
	Entire Run	---	2.8	8.3	7.8	5.8	2.2	**5.4**	**1.6**
Salmon River, South Fork	First Half	8.6	9.6	6.0	6.6	0.9	1.5	**5.5**	**4.7**
	Last Half	8.7	4.9	6.6	3.4	10.2	3.4	**6.2**	**5.4**
	Entire Run	8.7	6.2	6.5	4.3	5.9	2.9	**5.8**	**5.2**
Secesh River	First Half	3.8	---	9.1	14.8	1.2	5.2	**6.8**	**19.3**
	Last Half	2.5	---	7.1	4.5	4.9	3.3	**4.5**	**9.6**
	Entire Run	2.8	---	7.3	6.5	3.9	3.5	**4.8**	**12.1**
Valley Creek	First Half	5.1	---	---	---	7.5	12.9	**8.5**	**10.1**
	Last Half	8.9	---	---	---	7.4	2.9	**6.4**	**10.4**
	Entire Run	7.3	---	---	---	7.4	5.5	**6.7**	**10.3**
RealTime Select Composite	First Half	2.7	1.9	2.3	6.7	2.7	0.8	**2.9**	**3.2**
	Last Half	2.0	2.5	1.7	1.5	2.5	1.2	**1.9**	**4.9**
	Entire Run	2.2	2.4	1.8	2.6	2.5	1.1	**2.1**	**4.3**

Table D.1: Historical MADS for all 2001 Realtime Stocks tracked and forecasted more than two years.

Stock Name	Portion of Outmigration	Year							
		1995	1996	1997	1998	1999	2000	**Hist. Avg.**	**2001**
SNAKER	First Half	---	---	---	---	9.5	3.2	**6.4**	**3.3**
	Last Half	---	---	---	---	3.6	5.5	**4.6**	**5.4**
	Entire Run	---	---	---	---	4.7	4.9	**4.8**	**4.8**

Table D.2: Data used by program RealTime in 2001 to compute initial predictions (formula 2.5) for simple count stocks. Average historical run sizes[a] of the simple count stocks (runs-at-large) tracked and forecasted by RealTime in 2001. Average historical run sizes are used to predicted current year run sizes, $E(\hat{S})$ (Section 2.6.1), which are used to make initial predictions using the run percentage (RP) model.

Rearing	Type of Data	Stock	Passage Predictions made at	Expected 2001 Run Size, $\hat{E}(S)$	Observed 2001 Run Size
Wild	PIT-tag	Spring/Summer Yearling Chinook	Lower Granite Dam	9261	18,076
		Steehead Trout		5865	13,570
		Snake River Subyearling Chinook Salmon	McNary Dam	171	54
		Upper Columbia River Subyearling Chinook Salmon		1657	1210
		Snake River Yearling Chinook Salmon		7156	8782
		Snake River Sockeye Salmon		239	38
		Snake River Steelhead Trout		2093	2641
		Upper Columbia River Steelhead Trout		1071	191
		Snake and Upper Columbia River Steelhead Trout		3445	2833

Table D.2: Data used by program RealTime in 2001 to compute initial predictions (formula 2.5) for simple count stocks. Average historical run sizes[a] of the simple count stocks (runs-at-large) tracked and forecasted by RealTime in 2001. Average historical run sizes are used to predicted current year run sizes, $E(\hat{S})$ (Section 2.6.1), which are used to make initial predictions using the run percentage (RP) model.

Combined Wild and Hatchery	FPC Passage Indices	Subyearling Chinook Salmon	Rock Island Dam	16,897	22,651
		Yearling Chinook Salmon		29,604	6635
		Coho Salmon		33,677	45,437
		Sockeye Salmon		15,486	3032
		Steelhead Trout		20,050	17,914
		Subyearling Chinook Salmon	McNary Dam	7,771,641	10,777,847
		Yearling Chinook Salmon		2,169,615	2,299,489
		Coho Salmon		334,548	147,045
		Sockeye Salmon		655,423	284,965
		Steelhead Trout		722,976	562,611
		Subyearling Chinook Salmon	John Day Dam	1,452,962	2,849,766

a.Data Sources: PTAGIS and FPC Smolt Index Databases and RealTime program output as of 15 December 2001.